

THE GENUS *GRIMMIA* HEDW. (GRIMMIACEAE, MUSCI) IN RUSSIA РОД *GRIMMIA* HEDW. (GRIMMIACEAE, MUSCI) В РОССИИ

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Abstract

The revision of *Grimmia* collections from the territory of Russia is presented. Thirty one species are recognized, while *G. decipiens* and *G. trichophylla* are excluded from the Russian bryoflora. Descriptions, illustrations, comparisons with similar species, studied specimens and maps of distribution in Russia are presented for each species.

Резюме

Проведена ревизия рода *Grimmia* для территории России, где выявлен 31 вид, а нахождение *G. decipiens* и *G. trichophylla* не подтверждается. Для всех видов даны описания, иллюстрации, сравнения со сходными видами, а также перечислены все изученные образцы. Распространение видов показано также на картах.

INTRODUCTION

The genus *Grimmia* is difficult for species identification, and thus its treatments by different authors lead sometimes to more or less incongruent results. About 250 species of the genus were accepted in “Index Muscorum”, not counting *nominae nuda*e (Wijk & al., 1962, 1969), 123 species [69 of them as confirmed by recent revisions] – by Crosby & al. (1999), 71 – by Muñoz & Pando (2000), and 93 – by Greven (2003).

The genus got recently a lot of attention: it was revised for the territory of Japan (Deguchi, 1978), China (Cao & Vitt, 1986; Cao & al., 2003), Altai within Russia (Ignatov & Cao, 1994), North Europe (Nyholm, 1998), Europe (Greven, 1995; Maier & Geissler, 1995), Himalayas (Maier, 2002), South America (Muñoz, 1999), worldwide (Greven, 2003). Muñoz & Pando (2000) published results of their worldwide revision, including type citations, complete synonymy and distribution of each species up to the country level.

During these studies a lot of corrections were done for the territory of Russia, but the main amount of collections, especially from local herbaria remained under-studied. Thus the most recent existing revision of *Grimmia* for the whole area of Russia is the treatment of this genus in Savicz-Lyubitskaya & Smirnova (1970) handbook of acrocapitous mosses of the USSR.

This latter revision includes 27 species and 3 varieties which are treated here as species: *G. trichophylla* var. *tenuis* – *G. muehlenbeckii*, *G. tergestina* var. *poecilostoma* – *G. poecilostoma*, *G. hartmanii* var. *anomala* – *G. anomala*. In addition, these authors also included *G. orbicularis* under the name *G. pulvinata* var. *africana*. Three more species of *Grimmia* were reported by Savicz-Lyubitskaya & Smirnova (l. c.) as *Dryptodon* (*D. atratus*), *Hydrogrimmia* (*H. mollis*) and *Racomitrium* (*R. patens*). Thus these authors reported for USSR altogether 34 species of *Grimmia*, 29 of them from Russia.

Check-list of mosses of the former USSR (Ignatov & Afonina, 1992) includes 27 species for Russia (including *Hydrogrimmia*, *G. trichophylla* and *G. decipiens*, the two latter species based on erroneous data). Muñoz & Pando (2000) reported for Russia 30 species, adding *G. capillata*, *G. triformis* and *G. teretinervis*, as new for Russia, and raising the status of *G. poecilostoma* and *G. orbicularis* up to species level. Finally Ignatova & al. (2003) described one more Siberian species, *G. jacutica*.

The present revision is based on the study of herbarium collections from the main bryological herbaria where Russian material is well-represented: CSR, H, IRK, KPABG, KRS, LE, MHA, MW, PTZ, S, SASY, SVER, UUH, VLA.

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Grimmia Hedw., Sp. Musc. Frond.: 75.1801.

Type species: *Grimmia plagiopodia* Hedw. (lectotype, designated by Mårtensson, 1956: 156).

Plants medium-sized, more rarely small or robust, soft or rigid, in dense or loose, often easily separating tufts, patches or cushions, dark green, yellow green, brownish or blackish green, not or weakly to strongly hoary. Leaves ovate, ovate-lanceolate, lanceolate or linear-lanceolate, concave or keeled in distal part; margins entire, plane, incurved or recurved, often recurved on one side and plane on other side in proximal part of leaf; costa single, clearly or weakly delimited from laminal cells, \pm percurrent, semi-terete and ventrally canaliculate or flattened, rarely terete, in cross section semi-elliptic, semi-circular, round or reniform, sometimes irregularly angular, trapezoid, winged dorsally in distal part of leaf; lamina 1-2-(3)-stratose in distal 2/3, often more thick, rarely less thick at margins, usually unistratose at proximal 1/3 of leaf; upper and median laminal cells subquadrate, oblate to short rectangular, sometimes rounded-quadrate or irregular, with strong or moderately thickened, straight or sinuose walls, mostly smooth, rarely papillose or /and bulging, basal juxtacostal cells rectangular to linear, thick- or thin-walled, porose to nodulose or not porose, basal marginal cells usually shorter, pellucid, rarely quadrate or oblate, opaque, often with thin longitudinal and thick transverse walls, more rarely with uniformly thin longitudinal and transverse walls. Autoicus or dioicus. Androecia terminal, at shoot tips, or lateral, just below perichaetia. Setae short to long, straight, arcuate or sigmoid. Capsules immersed, emergent or exserted, symmetric or ventricose, ovoid or cylindric, smooth, furrowed or ribbed. Operculae plane or conic, rostrate or mamillate, columellae not attached to opercula. Annulus of three main types (Fig. 1): 1) composed of (2-)3-4 rows of thick-walled, but transparent cells with narrow lumen, becoming larger to upper rows, separating in spirals (affinis-type, according to Deguchi, 1978); 2) composed of small, round, thick-walled but transparent cells with round lumen, separating in groups or by single cells (elongata-type, l.c.); 3) several rows of subquadrate or transverse rectangular thick-walled, not transparent cells at the orifice (Schistidium-type, l.c., called also simple and persistent or not differentiated). Peristome teeth

orange-red, erect to spreading when dry, lanceolate, entire or cleft, not perforate or perforate to cibrose. Spores small, finely papillose. Calyptrae cucullate or mitrate. Gemmae in few species, multicellular, globular, with protuberant cells, developing on stalks or subsessile, on leaf apices, on dorsal or ventral side of costa.

The generic concept used in the present paper is a traditional one. Recently Ochyra & al. (2003) suggested to split *Grimmia* into four genera, segregating also *Dryptodon* (= *Grimmia* sect. *Rhabdogrimmia*, species with curved setae and ribbed capsules), *Guembelia* (group of species with flat, poorly defined costae) and *Orthogrimmia* (small species with keeled lanceolate leaves), remaining in *Grimmia* species with ventricose capsules. Though the core species of these groups are contrasting, the position of some species remains unclear (and probably will be more clear after expanded analysis which involves molecular data). So we leave the systematic discussion for the future, and by the same reason arrange species in alphabetical order.

The number of species in the genus (in the present circumscription) is different in the publications of different authors, i. e.: 123 species [69 of them as confirmed by recent revisions] (Crosby & al., 1999), 71 species (Muñoz & Pando, 2000) or 93 species (Greven, 2003).

Species of *Grimmia* are mostly distributed in cold and mountain regions of the world, where rocks and especially acid rocks are widespread (though some species prefer calcareous rocks and sometimes grow on soil in cold environments). The name is in honour of J. F. C. Grimm, 1737-1821, a medical doctor and botanist from Gotha, Germany.

NB: The careful explanation of some taxonomically important morphological characters of *Grimmia* is given by Loeske (1913), Deguchi (1978), and Muñoz (1998).

NB: Helpful suggestions on the slide preparation, cross sectioning, etc. are given by Maier (2002).

NB: Beautiful colorful pictures of many species of *Grimmia* are given as a supplement to the world revision of *Grimmia* by Greven (2003).

NB: Leaf length given in keys and description do not include hair-point length.

NB: The study of leaf cross section is very important for the species identification; the sections should be made mostly at distal 2/3-3/4 of leaf, if otherwise not indicated.

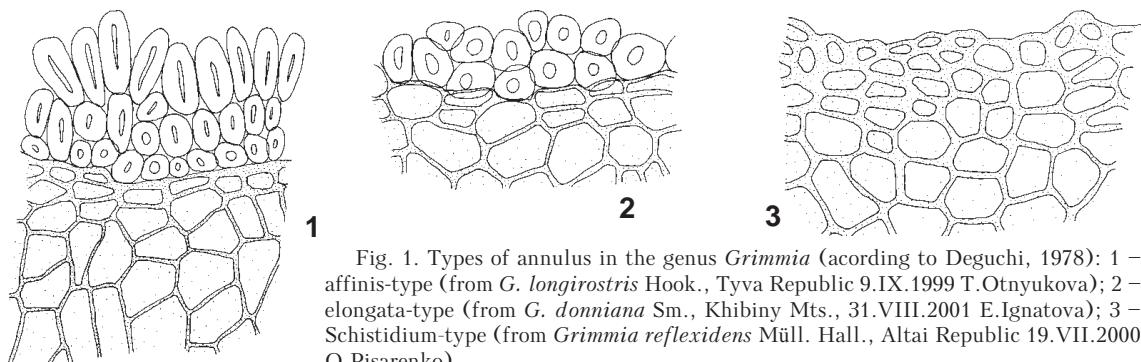


Fig. 1. Types of annulus in the genus *Grimmia* (according to Deguchi, 1978): 1 – affinis-type (from *G. longirostris* Hook., Tyva Republic 9.IX.1999 T.Otnyukova); 2 – elongata-type (from *G. donniana* Sm., Khibiny Mts., 31.VIII.2001 E.Ignatova); 3 – Schistidium-type (from *Grimmia reflexidens* Müll. Hall., Altai Republic 19.VII.2000 O.Pisarenko).

KEY FOR IDENTIFICATION
OF GRIMMIA IN RUSSIA

1. Leaves soft, broadly ovate; leaf cells 12-25 μm wide *G. mollis* (p. 146)
- Leaves rigid, linear, ovate-lanceolate or ovate; leaf cells 6-12(-14) μm wide 2
2. Capsules immersed into perichaetial leaves, setae shorter than 1 mm 3
- Capsules emergent to exserted (setae longer than 1 mm) or plants sterile 9
3. Plants robust, leaves (2.0-)2.5-4.0 mm long, from ovate base narrowed to long lanceolate acumen *G. pilifera* (p. 156)
- Plants small to medium-sized, leaves 1.0-2.0(-2.5) mm long, ovate to lanceolate . . . 4
4. Leaves canaliculate, not keeled in distal part, bistratose in distal 2/3 of leaf, costa weakly differentiated, flattened, semi-elliptical in cross section 5
- Leaves keeled in distal part, mostly unistratose or bistratose at margins in 1-5 cell rows, rarely mostly bistratose (*G. anodon*); costa differentiated, semi-circular in cross section 6
5. Capsules symmetric, setae erect, centrally attached; usually on calcareous substrates *G. tergestina* (p. 172)
- Capsules asymmetric, ventricose, setae sigmoid, excentrically attached; mostly on acidic or neutral substrates *G. poecilostoma* (p. 161)
6. Capsules symmetric, setae erect, centrally attached 7
- Capsules asymmetric, ventricose, setae sigmoid, excentrically attached 8
7. Leaf margins plane, basal marginal cells of stem leaves with uniformly thin longitudinal and transverse walls
- Leaf margins recurved, basal marginal cells of stem leaves with thin longitudinal and thick transverse walls *G. capillata* (p. 113)
8. Peristome absent *G. anodon* (p. 107)
- Peristome present *G. plagiopodia* (p. 161)
- 9(2). Basal marginal cells of stem leaves with uniformly thin longitudinal and transverse walls 10
- Basal marginal cells of stem leaves with thin longitudinal and thick transverse walls 13
10. Leaf margins always plane, never recurved; opercula low conic, mamillate *G. donniana* (p. 115)
- Leaf margins recurved in proximal part, at least on one side; opercula with short beak 11
11. Leaves long and narrow, linear-lanceolate, strongly flexuose to almost crisped when dry; basal paracostal cells with thick, porose to nodulose longitudinal walls and very thin transverse walls *G. incurva* (p. 131)
- Leaves ovate-lanceolate or lanceolate, slightly flexuose when dry; basal paracostal cells with moderately thickened and slightly porose longitudinal walls 12
12. Hyaline hair-points long (mostly longer than 0.3 mm); setae arcuate when moist *G. fuscolutea* (p. 124)
- Leaves with very short hyaline hair-points (usually not longer than 0.3 mm) or muticous; [setae erect when moist] *G. elongata* (p. 120)
- 13(9). Leaf margins always plane, never recurved 14
- Leaf margins recurved in proximal part, at least on one side 21

14. Upper laminal cells bulging 15
 — Upper laminal cells not bulging 16
15. Leaves with deep longitudinal plicae; upper laminal cells with scattered papillae *G. caespiticia* (p. 111)
 — Leaves not or weakly plicate; upper laminal cells never papillose . . . *G. alpestris* (p. 105)
16. Costa terete, prominent both dorsally and ventrally, round in cross section *G. teretinervis* (p. 170)
 — Costa semi-terete, not prominent ventrally, not round in cross section 17
17. Leaves keeled in distal part; costa differentiated, strongly prominent dorsally, semi-circular in cross section, with 2 ventral epidermal cells *G. montana* (p. 147)
 — Leaves canaliculate in distal part; costa weakly differentiated, slightly prominent dorsally or flattened, semi-elliptical in cross section, with (2-)3-6 ventral epidermal cells 18
18. Basal marginal cells of stem leaves oblate, opaque *G. laevigata* (p. 136)
 — Basal marginal cells of stem leaves quadrate or rectangular, not opaque 19
19. Leaves muticous, cucullate at apex *G. unicolor* (p. 179)
 — Leaves with hyaline hair-points 20
20. Leaves from ovate base tapering into long and narrow lanceolate acumen; perichaetal leaves similar to stem leaves; [capsules exserted] *G. ovalis* (p. 154)
 — Leaves from ovate base tapering into short and rather wide acumen; perichaetal leaves differentiated, filmy at base or at proximal 2/3, with very thin-walled basal cells; [capsules immersed] *G. tergestina*, *G. poecilostoma* (pp. 172, 161) [these two species could not be differentiated certainly without sporophytes]
- 21(13). Gemmae present 22
 — Gemmae absent 25
22. Leaves strongly contorted to crisped; gemmae subsessile on dorsal side of costa at base of upper leaves . . . *G. torquata* (p. 175)
 — Leaves erect or slightly flexuose; gemmae at leaf apices or on branched stalks on ventral side of costa at leaf base . . . 23
23. Gemmae on branched stalks on ventral side of costa at leaf base *G. muehlenbeckii* (p. 149)
 — Gemmae on leaf apices 24
24. Leaf lamina striolate, laminal cells with longitudinal cuticular ridges on both surfaces, looking like papillae in leaf cross section; gemmae yellowish . . . *G. anomala* (p. 111)
 — Leaf lamina smooth, without cuticular ridges; gemmae red-brown . . . *G. hartmannii* (p. 126)
- 25(21). Costa reniform in cross section, with 3-6 ventral epidermal cells 26
 — Costa semi-circular or angular in cross section, with 2 ventral epidermal cells 28
26. Leaves muticous, costa winged dorsally in distal part of leaf *G. ramondii* (p. 165)
 — Leaves with hyaline hair-points, not winged 27
27. Plants in dense tufts or cushions; leaves mostly bistratose in distal 2/3; autoicus, sporophytes frequent, capsules ovoid-cylindric, smooth, setae erect and straight *G. longirostris* (p. 139)
 — Plants in loose tufts or patches; leaves unistratose, bistratose in one cell row at margins; dioicus, sporophytes very rare, capsules ovoid, ribbed, setae arcuate when moist *G. jacutica* (p. 132)
28. Plants robust, leaves 2.5-4.5 mm long. .29
 — Plants not robust, leaves mostly to 2.0 (-2.5) mm long 30
29. Costa furrowed to winged on dorsal side in distal part of leaf, irregularly angled in cross section; upper laminal cells papillose, often also bulging; capsules ribbed, setae arcuate when moist *G. elatior* (p. 117)
 — Costa smooth on dorsal side, semi-circular in cross section; upper laminal cells not papillose or bulging; [capsules immersed, smooth, setae short, erect] *G. pilifera* (p. 156)
30. Costa weakly winged on dorsal side in distal part of leaf, irregularly angled or trapezoid in cross section . . . *G. muehlenbeckii* (p. 149)
 — Costa semi-terete, not winged, semi-circular in cross section 31
31. Leaves lanceolate 32
 — Leaves ovate 33
32. Leaves widely keeled in distal part, usually spirally twisted when dry; upper and

- median laminal cells incrassate and sinuose; capsules furrowed, setae arcuate when moist *G. funalis* (p. 123)
- Leaves narrowly keeled in distal part (blades forming < 40° angle), not spirally twisted when dry; upper and median laminal cells moderately incrassate and slightly sinuose; capsules smooth, setae erect and straight when moist . . . *G. reflexidens* (p. 167)
33. Hyaline hair-points long, terete; capsules usually present, ribbed; setae arcuate when moist 34
- Hyaline hair-points short to long, in sterile plants sometimes absent, widened and flattened at base, usually decurrent; [capsules smooth, immersed] 35
34. Perigonia lateral, just below perichaetia; calyptrae mitrate; peristome teeth entire, not or slightly perforate . . . *G. pulvinata* (p. 162)
- Perigonia terminal; calyptrae cucullate; peristome teeth cibrose *G. orbicularis* (p. 152)
35. Leaf lamina partially bistratose in distal part *G. anodon* (p. 107)
- Leaf lamina unistratose 36
36. Hyaline hair-points in upper and perichaetal leaves considerably widened and flattened at base, decurrent . *G. capillata* (p. 113)
- Hyaline hair-points in upper and perichaetal leaves slightly widened and flattened at base, not decurrent *G. plagiopodia* (p. 161)
1. ***Grimmia alpestris*** (Schleich. ex Web. et Mohr) Schleich. Cat. Pl. Helv. ed. 2: 29. 1808.
— *Trichostomum pulvinatum* var. *alpestre* Schleich. ex Web. et Mohr, Bot. Taschenb. 110. 1807. Figs. 2, 3.
- Plants in compact cushions, glaucous-green in upper part, blackish inside. Stems erect, 0.5-1.5 cm long, with central strand. Leaves appressed when dry, erect-spreading when moist, 1.0-1.8×0.4-0.5 mm, from oblong base gradually narrowing into lanceolate acumen, sharply keeled distally, slightly plicate; margins plane to incurved in distal part of leaf; costa differentiated, strongly prominent dorsally, semi-circular in cross section, with 2 ventral epidermal cells; hyaline hair-points to 1 mm long, almost smooth; lamina bistratose in upper 2/3 or mostly bistratose with unistratose strips, upper laminal cells isodiametric, 8-13 µm, rounded-quadrangular, with moderately thickened and not sinuose walls, strongly bulging, basal juxta-costal cells short rectangular to quadrate, 10-35×8-20 µm, with evenly thickened walls, basal marginal cells similar in shape and size, with thin longitudinal and thick transverse walls. Dioicous, sporophytes not rare. Setae straight, 2-4 mm. Capsules exserted, ovoid-cylindric, 1.0-1.8 mm long, chestnut, smooth, fusiform. Exothelial cells thick-walled, stomata at urn base lacking. Operculum low conic, mamillate. Annulus of Schistidium-type. Peristome teeth entire or slightly cleft distally, brownish, concolorous with the urn. Spores 10-13 µm. Calyptrae cucullate.
- SPECIMENS EXAMINED: **CAUCASUS:** North **Ossetia**, North Ossetian Reserve, 20.VII.1977, *L.I.Abramova* (MW); **Karachaevo-Cherkessia**, Teberda Reserve, Alibek Gorge, 2.VII.1995, #4/95, *Onipchenko* (MW); Alibek glacier, 27.VII.1955, *I.Patrobolova* (LE, MW); Chuchkhur Gorge, 9.VII.1998, #z-36, *A.Volkov* & *S.Zenyakin* (MW); Malyj Khutuj Gorge, 28.VIII.1999, #7/99, *Onipchenko* (MW); Azgek Gorge, 30.VII.1993, 8.VII.1994, 33/93, 17/94, *Onipchenko* (MW); Aksaut River, Kti-Teberda Gorge, 15.VIII.1979, #7/12, *E.E.Gogina* (MHA); **Krasnodar Territory**, Mzymta River basin, Achishkho Mt., 25.VI.1951, *Alper* (CSR); Mzymta River basin, Achishkho Mt., 14.VIII.2004, *T.Akatova* (CSR); **Adygeya**, Belaya River basin, Kut Mt., 17-19.VII.1996, *T.Akatova* (CSR, MHA); **URALS:** **Bashkortostan**, Burzyan Distr., Shulgant-Tash, 6.VI.2001, #03-32, *V.Zolotov* (MHA); **SIBERIA:** **Altai Republic**, Katun, 1.VIII.1915, *J.Grano* (H-Br); Tyuguryuk, 23.VI.1966 *L.Bardunov* & *L.Novak* (IRK); Kurkure Range, Kayakkatuyarykskij Creek, 1.VII.1991, #7/109, *Ignatov* (MHA); Kurkure Range, Altintash Creek, 16.VI.1989, *N.Zolotukhin* (MHA); **FAR EAST:** **Kamchatka**, South-Kamchatian Reserve, Koshelevskij volcano, 21-29.VII.1990, *I.V.Czernyadjeva* (LE); Ushkovskij volcano slope, 23.VII.2003, *I.V.Czernyadjeva* (LE).
- Distribution.** This species is not rare in mountains of Central and Northern Europe and North America, Turkey and Transcaucasia, scattered in Middle Asia. In Russia *G. alpestris* is rather common in Caucasus, sporadically found in mountain areas of southern Siberia and Kamchatka, and only one locality in South Urals (Bashkortostan) is known. It grows usually in alpine belt, more rarely below tree-line, at 1800-3800 m alt., on neutral or basic rocks; the single collection from Bashkortostan was made at 500 m alt., on calcareous substrate.
- Differentiation.** *Grimmia alpestris* can be confused with *G. caespiticia* (see comments to this species) or *G. reflexidens*. It differs from the latter species mainly in sporophyte characters: capsules chestnut, fusiform (vs. stramineous, ovoid-cylindric in *G. reflexidens*), exothelial cells thick-walled (vs. thin-walled),

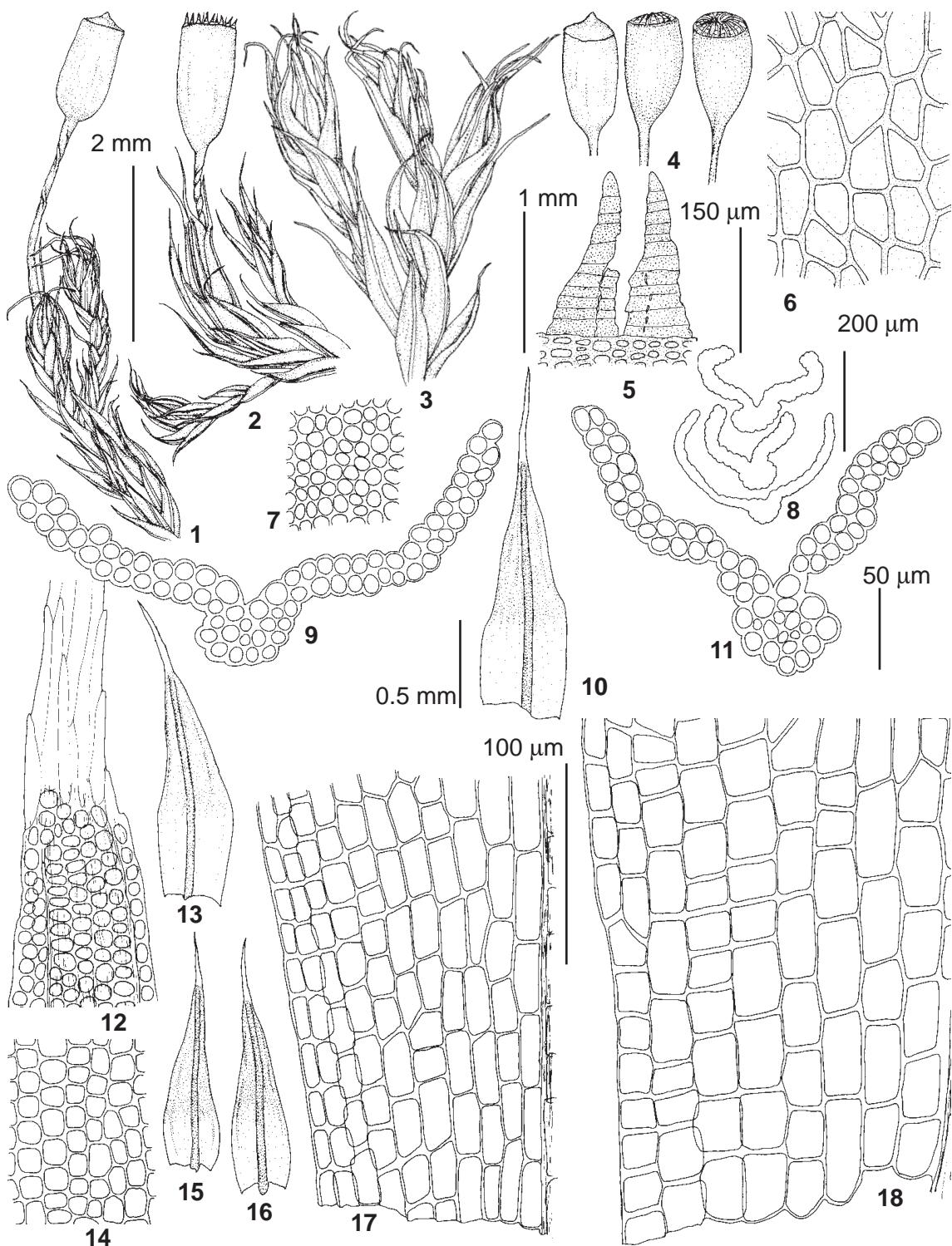


Fig. 2. *Grimmia alpestris* (Schleich. ex Web. et Mohr) Schleich. (from Bashkortostan, V. Zolotov, #03-32): 1-3 – habit; 4 – capsules; 5 – part of peristome; 6 – exothecium; 7 – upper leaf cells; 8-9, 11 – leaf transverse sections; 10, 13, 15-16 – leaves; 12 – base of hair-point and upper leaf cells; 14 – median leaf cells; 17-18 – basal leaf cells. Scale bars: 2 mm for 1-2, 4; 1 mm for 3; 0.5 mm for 10, 13, 15-16; 50 µm for 9, 11; 100 µm for 6-7, 12, 14, 17-18; 150 µm for 5; 200 µm for 8.

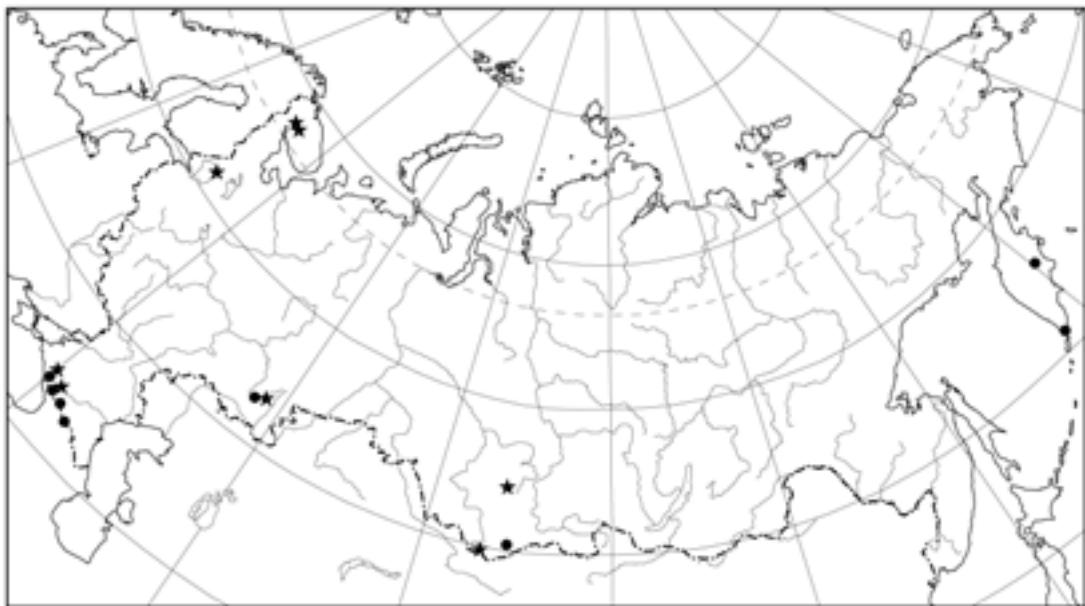


Fig. 3. Distribution of *Grimmia alpestris* (Schleich. ex Web. et Mohr) Schleich. (circles) and *Grimmia anomala* Hampe ex Schimp. (stars)

stomata absent (vs. present at urn base), peristome teeth brownish, concolorous with the urn (vs. orange, contrasting in color with the urn). Sterile specimens are sometimes difficult of identify because some forms of *G. reflexidens* are very close to *G. alpestris* in gametophyte characters sharing plane leaf margins, partially bistratose lamina and bulging upper laminal cells. However, such forms of *G. reflexidens* are very rare in Russian material, and this species can usually be recognized by narrowly recurved margin in middle part of leaf, at least on one side, mostly not or very slightly bulging cells and not glaucous plants.

2. *Grimmia anodon* B.S.G., Bryol. Europ. 3: 110. 236. 1845. Figs. 4, 5.

Plants in dense, low tufts, dark-green to blakish or brown, sometimes hoary. Stems erect, 0.5–1 cm long, usually with numerous thin sterile shoots with small muticous leaves. Leaves appressed when dry, erect-spreading when moist, upper and perichaetal leaves enlarged, 1.0–2.0×0.4–0.8 mm, oblong to ovate, concave, keeled distally, not plicate; margins plane in distal part of leaf, slightly recurved in proximal or middle part at one or both sides; costa clearly differentiated from laminal cells, narrow, widened distally, slightly prominent dorsally, semi-circular, with two ventral cells in cross section; hyaline hair-points short to absent in lower leaves or leaves of sterile shoots, long in upper and

perichaetal leaves, weakly denticulate to almost smooth, widened and flattened at base; lamina mostly unistratose, with bistratose margins, or partly bistratose in distal part of leaf; upper and median laminal cells rounded-quadrata to short rectangular, 10–20×8–12 µm, rather thin-walled and slightly sinuose, proximal juxta-costal cells rectangular, proximal marginal cells short rectangular, with thin longitudinal and thick transverse walls. Autoicous, androecia terminal, mostly with sporophytes. Setae short, to 0.5 mm, curved, eccentrically attached to the capsule. Capsules immersed, asymmetric, ventricose, 0.7–1.0 mm long, rounded, smooth, with wide mouth when open. Annulus of elongata-type. Peristome absent. Operculum plane-convex, mamillate. Spores 8–10 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:** **Karelia**, Ruskeala, Korpikallio, 15.VII.1876, V.F.Brotherus (H); Sortavala, 13.VI.1930, V.Kujela (H); **Moscow Province**, Lyubertzy Distr., Dzerzhinskij, 6.VII.1987, Ignatov (MHA); **Samara Province**, Syzran' Distr., Usol'e village, 24.VI.1926, #1/33, E.Schtkenberg (LE, MW); Syzran Distr., Zhiguli, 13.VII.1910, I.A.Vereitinov (LE); Syzran Distr., Zhiguli, Lysaya Gora, 15.VI.1910, I.A.Vereitinov (LE); Morkvashi village, Kamennaya Gora (Zhiguli), 4.VII.1925, #4/13, E.Schtkenberg (LE, MW); **Volgograd Province**, Sredne-Akhtubinskij Distr., 22.VI.1993, #169, S.Suragina (MHA); Kletskij Distr., Kremenskaya, 7.VIII.1999, Ignatov (MHA); **Astrakhan Province**, mons Bogdo, 30.IV.1926, #15, V.P.Savicz (MW, MHA, LE); Bogdo, 5.V.1923, L.Kazakevich (LE, MW); Bolshoe Bogdo Mt., 24.V.1992, V.Sagalaev, 2-3.V.2002, 14.VII.2002, S.Suragina (MHA);

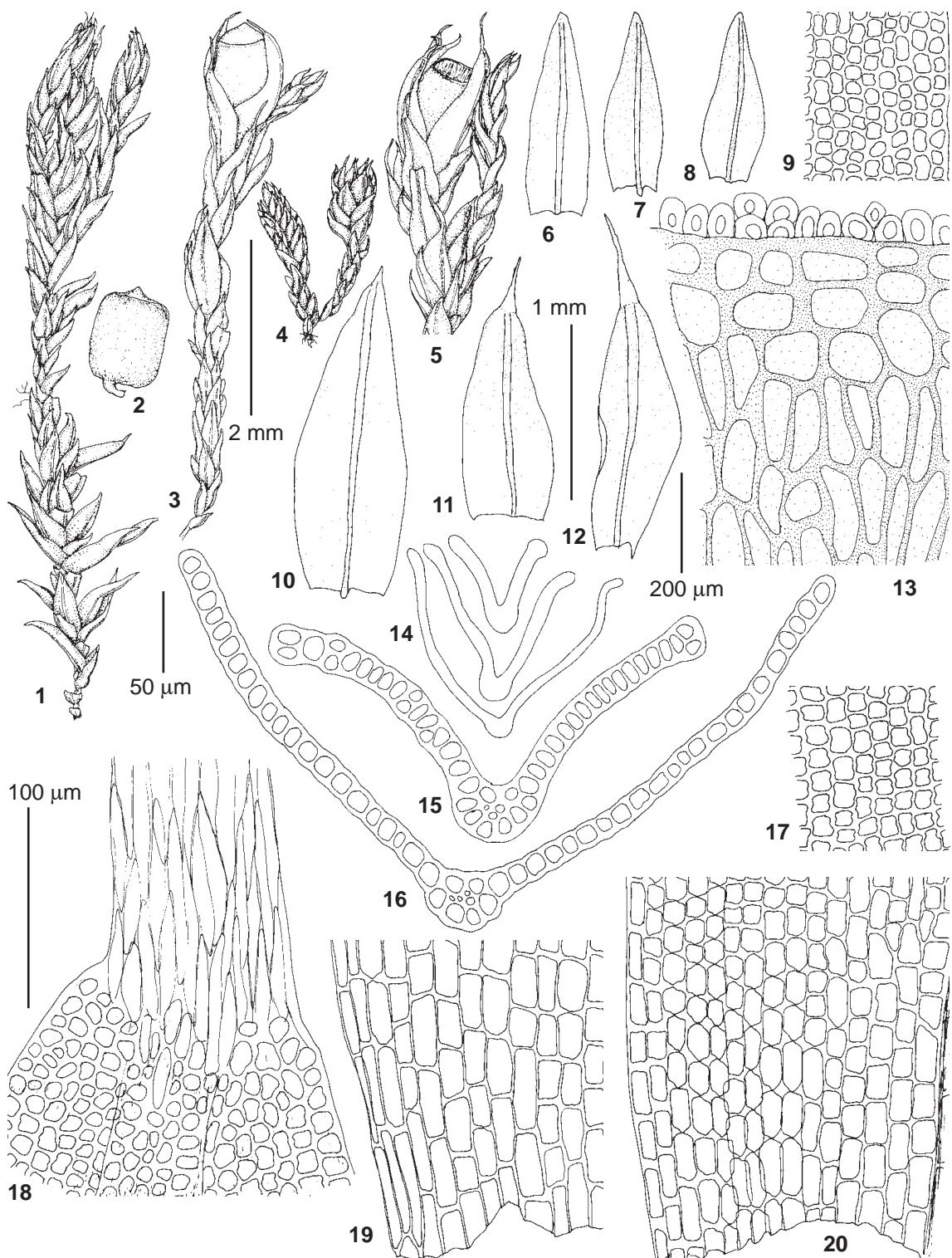


Fig. 4. *Grimmia anodon* B. S. G. (from Astrakhan Province, 9.V.1997, I. Zemlyanskaya): 1, 4 – habit (sterile shoots); 2 – capsule; 3, 5 – habit (fertile plants); 6-8 – leaves from sterile shoots; 9 – upper leaf cells; 10 – upper leaf; 11-12 – perichaetal leaves; 13 – exothecium; 14-16 – leaf transverse sections; 17 – median leaf cells; 18 – base of hair-point and upper leaf cells; 19-20 – basal leaf cells. Scale bars: 2 mm for 1-5; 1 mm for 6-8, 10-12; 50 µm for 15-16; 100 µm for 9, 13, 17-20; 200 µm for 14.

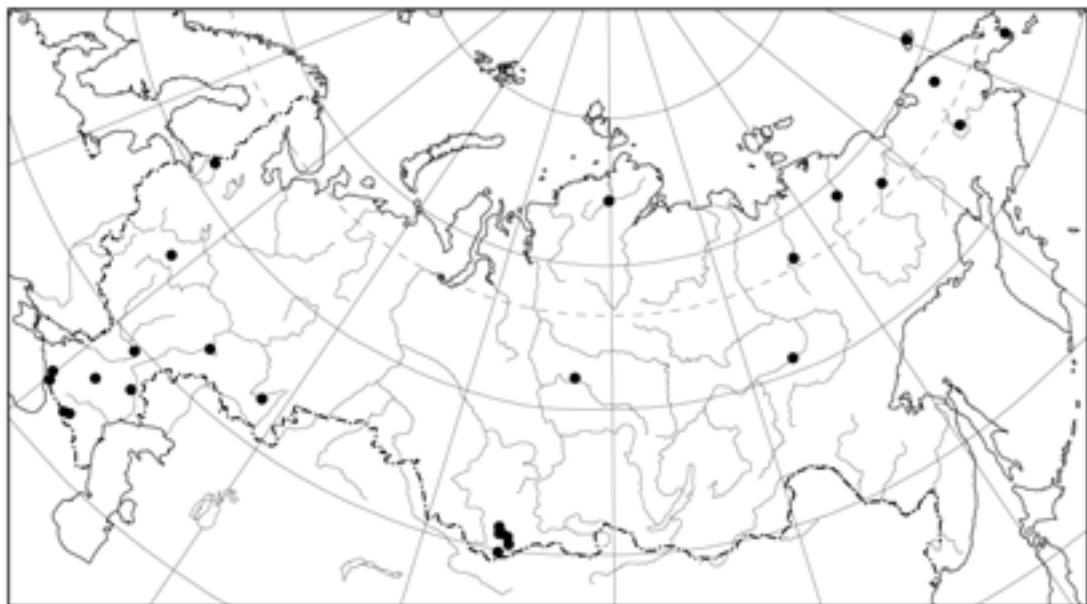


Fig. 5. Distribution of *Grimmia anodon* B.S.G. in Russia.

Kalmykiya, Manych Distr., Chalon-Khamur, Manych River valley, 17.IX.1924, #45, *L.Kazakevicz* (LE, MW);

CAUCASUS: Kabardino-Balkaria, Chegem River Gorge, 5.08.1998, *Z.Kharzinov* (KBNG); Sukan River Gorge, 10.10.1999, *Z.Kharzinov* (KBNG); Baksan River Gorge near Adyl-Su Creek mouth, 27.07.2002, *Z.Kharzinov* (KBNG); **Krasnodar Territory**, Caucasian Reserve, Tryu-Yatyrgvarta Mts., 16.VII.1997, *T.Akatova* (CSR); **Adygeya**, Oshten Mt., 14.VIII.1992, *T.Akatova* (CSR, MHA); **URALS: Bashkortostan**, Shulgan-Tash Reserve, 2001, #02-49, *V.Zolotov* (MHA); **SIBERIA: Altai Republic**, Kosh-Agach, Tabozhok Creek, 29-30.VII.1992, 7.VIII.1992, #30/4, #30/5, 31/3, #30/14, *Ignatov* (MHA); Kosh-Agach, Kokorya Creek, 4.VIII.1992, #32/17, *Ignatov* (MHA); Tokpak Creek, 24.VII.1993, #36/359, *Ignatov* (MHA); Bogoyash Creek, 27.VII.1993, #36/340, *Ignatov* (MHA); Karakem River, 18-23.VI.1989, #0/480, #0/721, 0/722, *Ignatov* (MHA); Chulyshman River at Uandu Creek mouth, 2.VIII.1993, #36/301, *Ignatov* (MHA); Chulyshman River, Yazula, Bashtu Mt., 25.VI.1989, #0/725, *Ignatov* (MHA); Chulyshman River, Berekhtuyaryk, 26.VI.1989, #0/478, *Ignatov* (MHA); Shapshal Range, Tutuoyuk Creek, 15.VII.1990, *N.Zolotukhin & E.Koroleva* (MHA); Kayakkatuyarykskij Creek, 1.VII.1991, #7/113, *Ignatov* (MHA); Shapshal Range, Yakhansoru Lake, 28.VI.1990, *N.Zolotukhin* (MHA); Kayra Creek, 14.VII.1991, #13/50, *Ignatov* (MHA); **Krasnoyarsk Territory**, Taimyr, Ledyanaya Bay, 23 & 31.VII.2004, 12.VIII.2004, *V.Fedorov* (MW); Evenkiya, Bjikit Distr., Tanimakit River, 31.VIII.1989, *G.Lunina* (MHA); **Yakutia**, Khangalasskij Distr., Lenskie Stolby, 17.VIII.2000, #00-122, *Ignatov* (MHA); Verkhoyansk Distr., Orto-Sala River, Petrusha Lake, 25.VII.1989, *E.G.Nikolin* (SASY, MW); Srednekolymskij Distr., Kolyma River at Labuya settlement, 7.X.2002, *E.I.Ivanova* (SASY, MW); Indigirka River basin, Injali River, 19.VI.1976, #10, *O.M.Afonina* (LE); **FAR EAST: Chukotka**, Senyavin Strait, Yanrakynnot Settlement, 26.VII.1976, *O.M.Afonina* (LE); Utaveem River, 29.VII.1970, *B.A.Yurtzev* (LE); Chegitun' River, 9.VIII.1991, *O.M.Afonina* (LE); Palavaam

River, 20.VII.1989, *O.M.Afonina* (LE); Vrangel Island, Gusinaya River, 27.VII.1980, *O.M.Afonina* (LE).

Distribution. Rather widespread species throughout Europe except northernmost regions, in North Africa, Transcaucasian countries, Turkey, Middle East, Middle Asia, Iran, Pakistan, India, China, and Mongolia, North and South America. Known from lowland European Russia, from Moscow to Astrakhan Province and Kalmykia, and from two localities in Karelia, rather common in dry areas of Altai Mts.; from other regions represented by scattered collections: Chukotka and Vrangel Island, Yakutia, Taimyr and Central part of Krasnoyarsk Territory, South Urals, and in Russian part of Caucasus found in few localities in Kabardino-Balkaria, Krasnodar Territory, and Adygea. Grows from sea level to 2500 m alt., in dry habitats, mostly calcareous.

Differentiation. Most collections of *G. anodon* have sporophytes and can be easily recognised by immersed ventricose capsules on curved setae, without peristome (*Schistidium flaccidum*, species also having immersed capsules and mostly lacking peristome differs by straight seta attached to the center of urn base). Sterile plants of *G. anodon* can be differentiated from other species by the combination of ovate, keeled, mostly muticous leaves (except only uppermost ones), unistratose

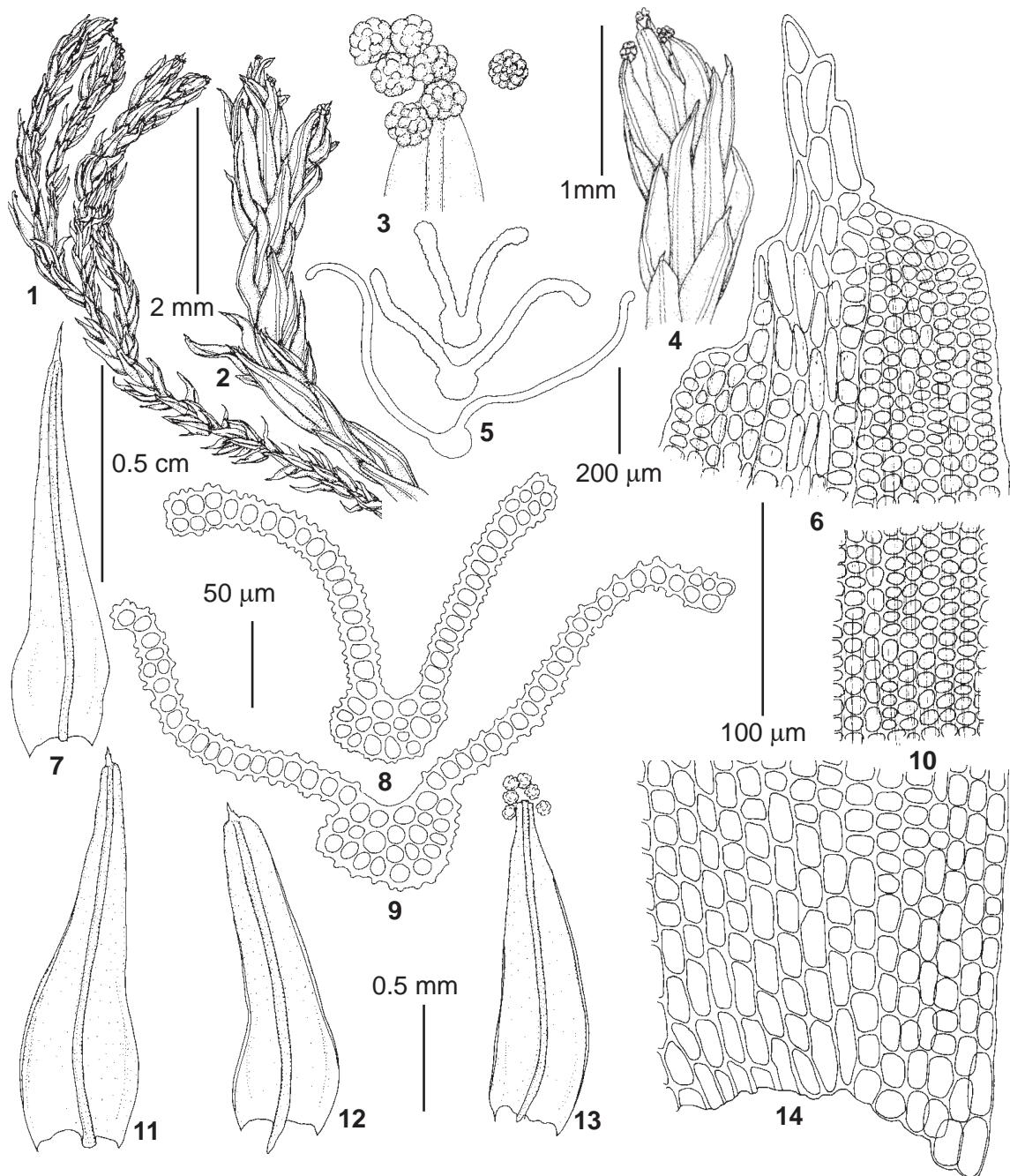


Fig. 6. *Grimmia anomala* Hampe ex Schimp. (1-2, 5, 8 - from Bashkortostan, V.Zolotov, #06-34; 3-4, 6-7, 9-14 - from Altai Republic, 15.VII.2000, O.Pisarenko): 1-2, 4 - habit; 3 - leaf tip bearing gemmae; 5, 8-9 - leaf transverse sections; 6 - hair-point and upper leaf cells; 7, 11-13 - leaves; 10 - median leaf cells; 14 - basal leaf cells. Scale bars: 0.5 cm for 1; 2 mm for 2; 1 mm for 4; 0.5 mm for 7, 11-13; 50 µm for 8-9; 100 µm for 6, 10, 14; 200 µm for 3, 5.

lamina with bistratose strips or margins, and narrow costa. *Grimmia tergestina* and *G. poecilostoma* differ from *G. anodon* by concave leaves with plane margins, wide but weakly differentiated costa and lamina distally comple-

tely bistratose. *Grimmia plagiopodia*, species most similar by gametophyte characters to *G. anodon* can be recognised by always unistratose leaf lamina (vs. partly bistratose or with bistratose margins in 1-2 cell rows in *G. anodon*) and

densely denticulate hyaline hair-points (vs. weakly denticulate to almost smooth in *G. anodon*). Sterile plants of *G. capillata* can be recognized from *G. anodon* by always unistratose leaf lamina.

3. *Grimmia anomala* Hampe ex Schimp., Syn. Musc. Eur. ed. 2: 270. 1876. — *Grimmia hartmanii* var. *anomala* (Hampe ex Schimp.) Mönk., Laubm. Eur.: 369. 1927. Figs. 6, 3.

Plants in loose rigid patches, dark green above, brownish below. Stems prostrate to ascending, moderately branching, 1-2[-3] cm long, with well-developed central strand. Leaves erect, loosely appressed to imbricate, sharply keeled distally, 1.5-2.2×0.5-0.6 mm, from ovate base gradually tapering into wide or narrow acumen, acute or obtuse, rounded or truncate at apex, in upper leaves eroded due to gemmae formation; margins plane or weakly recurved in distal part of leaf, more strongly recurved on one or both sides below; costa differentiated, strongly prominent dorsally, semi-circular in cross section, with 2-3(-4) ventral epidermal cells; hyaline hair-points very short, weakly denticulate; lamina unistratose, bistratose in 1-4 cell rows at margins; upper and median laminal cells rounded-quadrata to ovata, 7-8 µm, not or slightly sinuose, with longitudinal cuticular ridges on both surfaces, looking as papillae in leaf cross section and striolate in surface view; basal juxtastral cells short rectangular, 8-10×15-25 µm, with moderately thickened, not porose walls, basal marginal cells with thin longitudinal and thick transverse walls. Gemmae numerous, multicellular, globose, 70-80(-100) µm in diameter, yellowish green or yellow, becoming brownish later, with protuberant surface cells, developing on eroded apices of normally developed upper leaves. Dioicous, sporophytes rare, not known from the territory of Russia. [Setae 3-5 mm, flexuose when dry, erect or curved when moist. Capsules exserted, ovoid, smooth, 1.5-2 mm long. Operculum conic, with rather long erect or oblique beak. Annulus of affinis-type. Peristome teeth orange-red, entire. Spores 14 µm. Calyptrae mitrate].

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:**

Murman Province, Laplandskij Reserve, Salnye tundra, VII.2004, B35/1a-04, B24/1-04, O.A.Belkina (KPABG); Khibiny Mts., Vudjavrchorr Mt., 6.VIII.2004, I.V.Blinova (KPABG); **Karelia**, Loimalajoki, VII.1876, V.F.Brotherus (H); **CAUCASUS: Karachaevo-Cherkessia**, Teberda Reserve, Teberda River upper course, Beik-Ala, VIII.1947, I.I.Tumadzhanov (LE); **Krasnodar Territory**, Caucasian Reserve, Pseashho, 27.VIII.1909, I.Palamarchuk (LE); Shakhe River basin, Khuko Ridge, 20.VIII.1995, T.Akatova (CSR); Urushten River basin, Dzhuga Mt., 5.VIII.1988, T.Akatova (CSR); Mzymta River basin, Achishkho Mt., 14.VIII.2004, T.Akatova (CSR); **URALS: Bashkortostan**, Burzyan Distr., Shulgan-Tash, 6-9.VI.2001, #06-34, 06-36, 06-38, V.Zolotov (MHA); **SIBERIA: Altai**

Republic: Katunskij Reserve, Katunskij Range, Talmen'e Lake, 15.VII.2000, O.Pisarenko (MW); **Kemerovo Province**, Kuznetzkij Alatau Mts., Barkhatnyj Range, 16.VI.2000, Krasnaya River, 20.VI.2002, Chemodan Mt., Kedrovij Creek, 11.IX.2004, Pokatnyj Creek, 12.IX.2004, O.Pisarenko (NS).

Distribution. Mountain regions of Europe, from Scandinavia to Spain, North America (Canada and northern states of U.S.A.), Asia (Japan and India). Rare throughout its range. In Russia *G. anomala* was reported only from Caucasus until recently (records from Sakhalin Island were based on erroneously identified specimens, see the discussion under *G. hartmanii*); in 1990-2000 was also found in Altai Mts. and Kuznetzkij Alatau (O.Yu.Pisarenko), Bashkortostan (V.I.Zolotov), and Kola Peninsula (O.A.Belkina, I.V.Blinova). In the Caucasus it grows in the forest belt (beech, fir or pine forests) and just above tree-line (*Rhododendron* stands). In the Altai and Kuznetzkij Alatau Mts. it is found on boulders at high-grass subalpine meadows and on rock outcrops, in Bashkortostan in pine forests, and in Murmansk Province in birch forest, on open slope and on rock in a stream. It occurs both on acidic and basic rocks.

Differentiation. The main diagnostic characters of *Grimmia anomala* are the striolate lamina due to well-developed longitudinal cuticular ridges that resemble papillae when viewed in transverse section, and also the usually present yellowish multicellular gemmae at apices of upper leaves. The gemmae of *G. anomala* are similar to those of *G. hartmanii*, and the former species was sometimes treated as a variety of the latter; however, both species have stable differences discussed under *G. hartmanii*.

4. *Grimmia caespiticia* (Brid.) Jur., Laubm.-Fl. Oesterr.-Ung.: 172. 1882. — *Campylopus caespiticus* Brid., Muscol. Recent. Suppl. 4: 77. 1818 ["1819"]. Figs. 7, 8.

Plants in small, dense, fragile tufts, glaucous-green or dark green to blackish, not hoary. Stems erect, 0.5-1.5 cm long, with central strand. Leaves erect, with incurved tips, appressed when dry, erect-spreading when moist, 1.0-1.9×0.4-0.5 mm, from oblong base gradually tapering into lanceolate acumen, cucullate at apex, sharply keeled distally, with deep longitudinal plicae formed of several rows of more thick-walled narrow and longer cells; margins plane in proximal part, incurved in distal part; costa differentiated, strongly prominent dorsally, semi-circular or angular in cross section,

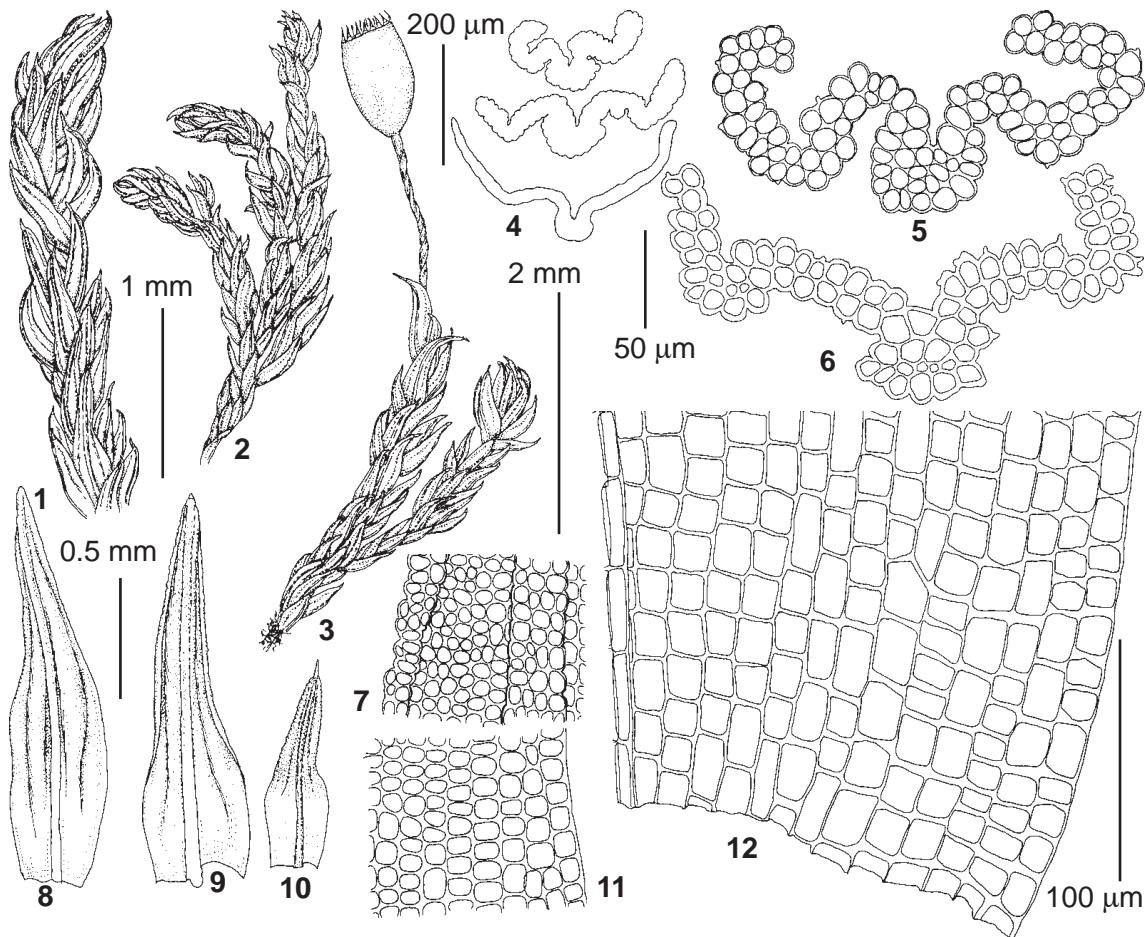


Fig. 7. *Grimmia caespiticia* (Brid.) Jur. (from Altai Republic, 11.VII.2000 O.Pisarenko): 1-3 – habit; 4-6 – leaf transverse sections; 7 – upper leaf cells; 8-10 – leaves; 11 – median leaf cells; 12 – basal leaf cells. Scale bars: 2 mm for 2-3; 1 mm for 1; 0.5 mm for 8-10; 50 µm for 5-6; 100 µm for 7, 10-12; 200 µm for 4.

with 2 ventral epidermal cells; hyaline hair-points usually short, to 0.5 mm long in upper leaves, almost smooth, mostly ca. 0.1 mm long or absent; lamina mostly bistratose in distal 2/3, partially 1- or 3-stratose, upper laminal cells isodiametric, 8-11 µm, rounded-quadrangular, with evenly thickened walls, strongly bulging and with scattered papillae, median laminal cells short rectangular, 10-25×8-10 µm, walls not sinuose, basal juxtacostal cells short rectangular and quadrangular, 10-35×10-15 µm, not porose or sinuose, basal marginal cells similar in shape and size, with thin longitudinal and thick transverse walls. Dioicous, sporophytes frequent. Androecia terminal. Setae 2-2.5 mm, straight. Capsules exserted, ovoid-cylindric, 1-1.5 mm long, smooth, chestnut. Exothelial cells thick-walled, stomata at urn base present. Operculum low conic, with short oblique beak or more rarely mamillate. Annulus of Schistidium-type. Peristome teeth entire or slightly cleft distally, chestnut, of the same color that the urn. Spores 10-14 µm. Calyptrae cucullate.

SPECIMENS EXAMINED: **CAUCASUS:** Kabardino-Balkaria, Elbrus Mt. surroundings, Adyl-Su River, Dzhankaut glacier, X.1994, #31, *I.Pospelov* (MW); North Ossetia, in alpe Zomorasch pr. Rex, ad fl.Terek, #22, *A.H. & V.F.Brotherus* (H-SOL); Karachaevo-Cherkessia, Teberda Reserve, Alibek Gorge, 3.X.1989, *Onipchenko* (MHA); Mussachitara Mt., 6.VIII.1986, *Ignatova* (MHA); Chuchkhr-Buulgen pass, 30.VII.1998, #z-39, *A.Volkov & S.Zenyakin* (MW); Northern Klukhor, 11.IX.1994, #200/94, *Onipchenko* (MW); Klukhorskoe Lake, 14.IX.1954, *I.Patrabolova* (LE); Gitche-Murudzhu, 9.IX.1994, #183/94, *Onipchenko* (MW); Ullu-Muridzhu, 8.VIII.1986, *Ignatova* (MW); M.Khatipara, 19.VIII.1995, #113/95, *Onipchenko* (MW); Malaya Khatipara Gorge, 3.VIII.1986, *Ignatova* (MHA); Krasnodar Territory, Uruschten River basin, Alous Mt., 12.VIII.1994, 17.VII.2002, *T.Akatova* (CSR, MHA); Dzhuga Mt., 5.VIII.1988, *T.Akatova* (CSR, MHA); Mzymta River basin, Aishkho Ridge, 5.VII.1951, *V.Alper* (CSR, MHA); Adygeya, Belaya River basin, Kut Mt., 21.VII.1996, *T.Akatova* (CSR); **SIBERIA:** Altai Republic, Katunskij Reserve, 11.VII.2000, *O.Pisarenko* (MW); Krasnoyarsk Territory, Western Sayan Mts., Karasu [Kara-Sug] River upper course, 6.VII.1968, *L.V.Bardunov* (IRK, MHA); Khakassia, Ordzhonikidzenskij Distr., Zolotogorskij settlement, 15.VII.1970, *A.Vasiljev* (IRK).

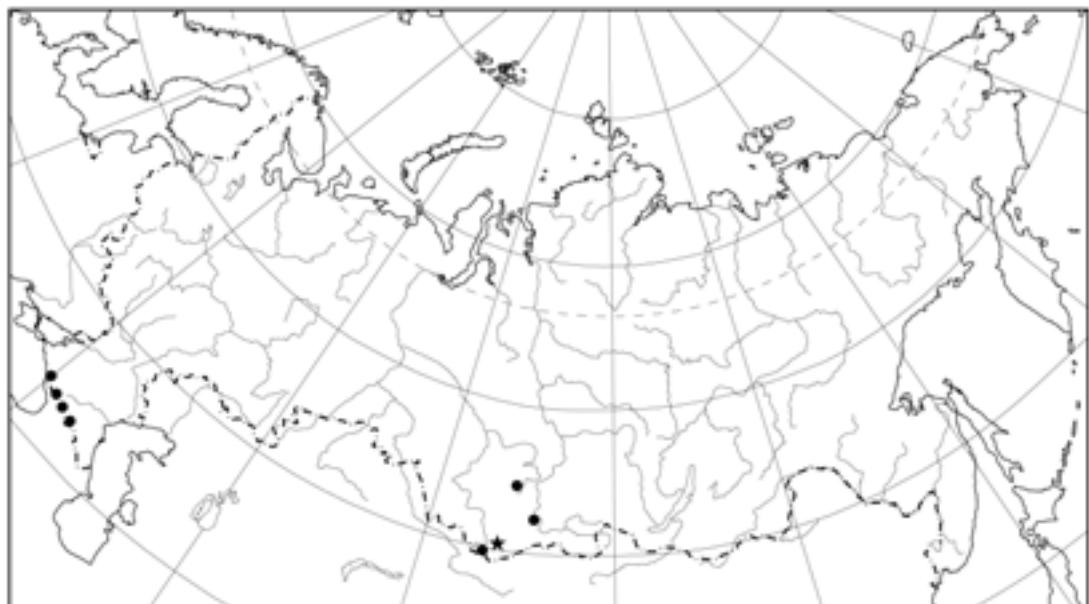


Fig. 8. Distribution of *Grimmia caespiticia* (Brid.) Jur. (circles) and *Grimmia capillata* De Not. (star) in Russia.

Distribution. *Grimmia caespiticia* is distributed in the mountains of Central and Southern Europe, Turkey, western coastal areas of North America; in Russia it is known from several localities in Caucasus and mountains of southern Siberia (Altai and Western Sayan Mts.). It grows above tree line, on exposed acidic and neutral rocks.

Grimmia caespiticia was erroneously reported from Urals and Arctic Siberia (Savicz-Lyubitzkaya, Smirnova, 1970), Russian European Arctic and Eastern Siberia (Ignatov & Afonina, 1992). Specimens cited by Ignatov & Cao (1994) from Altai Mts. belong to *Coscinodon cribrosus*, but *G. caespiticia* was collected in Altai later (O. Pisarenko, MW).

Differentiation. *Grimmia caespiticia* is similar to *G. alpestris* in gametophyte characters, sharing distally bistratose lamina, incurved margins, and strongly bulging laminal cells. However, the leaves of *G. alpestris* are less deeply plicate, lacking narrow thick-walled cells at the most deep part of the plicae, the upper laminal cells never have papillae, and the urn lacks stomata (the latter two characters are the most reliable for differentiation). Sterile specimens could be certainly recognized only by presence or absence of papillae of distal laminal cells. Sterile plants of *G. caespiticia* also can be confused with sterile *Coscinodon cribrosus*, another species with deeply

plicate leaves; but distal laminal cells of *Coscinodon cribrosus* are never bulging or papillose, and hyaline hair-points of upper and perichaetial leaves are much longer and flattened basally, whereas in *G. caespiticia* hair points are shorter than 0.5 mm and terete throughout.

5. *Grimmia capillata* De Not., Mem. Reale Accad. Sci. Torino 39: 248. 1836. — *Grimmia mesopotamica* Schiffn., Ann. K. K. Naturhist. Hofmus. 27: 488. 1913. Figs. 9, 8.

Plants in dense, easily separating tufts, dark-green above, brownish in lower part, not very hoary. Stems erect, to 1 cm long, with evenly arranged leaves. Leaves appressed to imbricate when dry, erect-spreading when moist, sometimes 3-ranked, 0.9–1.2×0.4–0.5 mm, ovate to ovate-lanceolate, concave, keeled in distal part, not plicate; margins plane to slightly recurved distally, recurved on both sides proximally; costa clearly differentiated, thin, widened in distal part of leaf, prominent dorsally, semi-circular in cross section, 2 cells wide ventrally, percurrent; hyaline hair-points short or absent in lower leaves and leaves of sterile shoots, rather long in perichaetial leaves; lamina unistratose throughout, upper and median cells rounded-quadrate to short rectangular, 7–22×9–13 µm, with not or slightly sinuose walls, basal juxta-costal cells elongate rectangular, basal marginal cells shorter, rectangular, with thin longitudinal and thick transverse walls. Autoicous, usually with sporophytes. Perichaetial leaves much longer than vegetative leaves, 2–2.5×0.4–0.5 mm, hyaline hair-points to 1 mm long, denticulate,

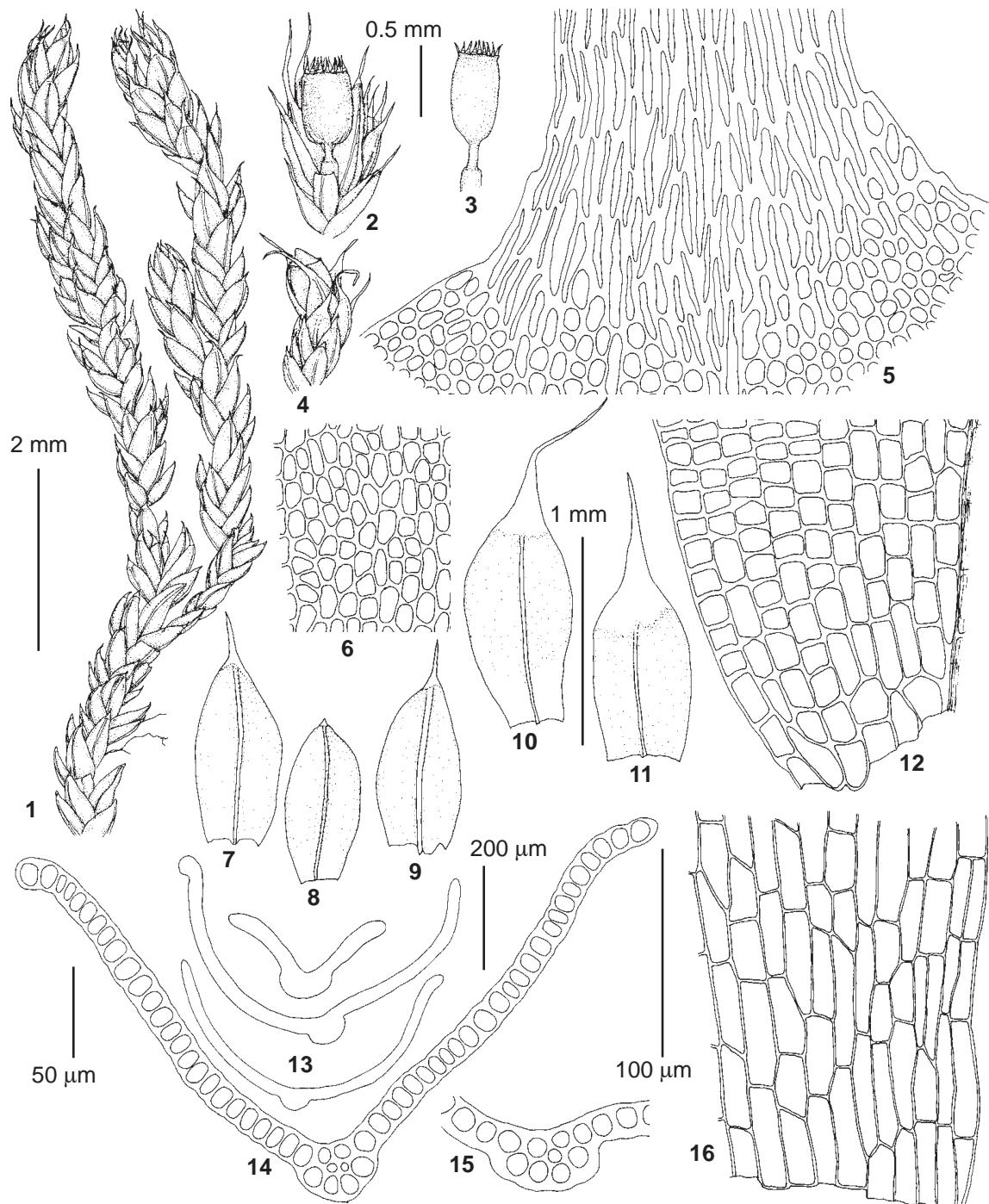
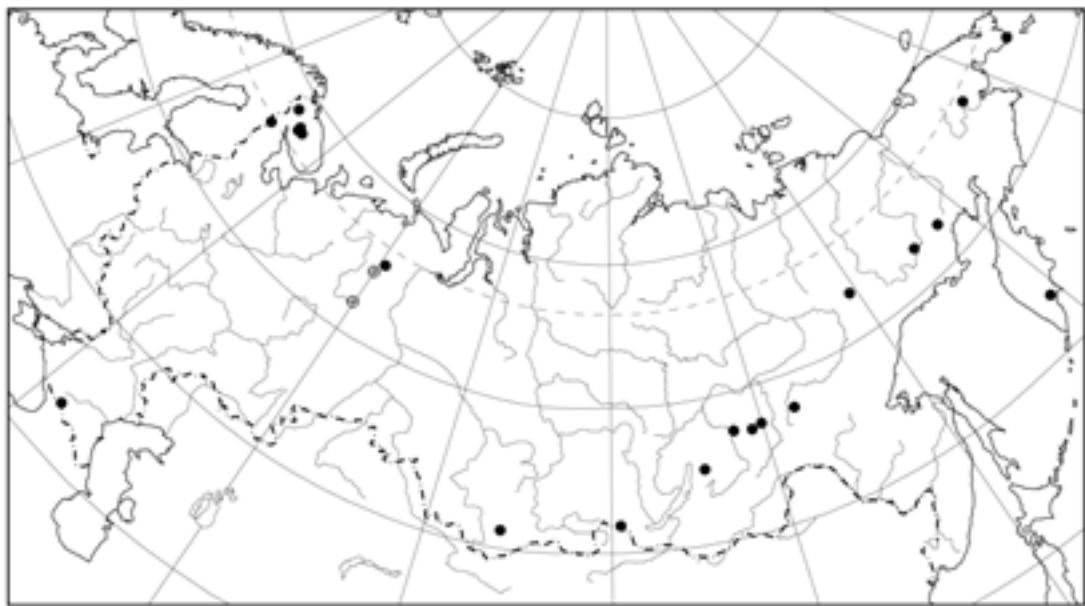


Fig. 9. *Grimmia capillata* De Not. (from Altai Republic, 23.VII.1966, L.V.Bardunov): 1 – habit; 2-4 – capsules; 5 – base of hair-point and upper leaf cells; 6 – median leaf cells; 7-9 – leaves; 10-11 – perichaetial leaves; 12 – basal cells of vegetative leaf; 13-15 – leaf transverse sections; 16 – basal cells of perichaetial leaf. Scale bars: 2 mm for 1; 1 mm for 2-4; 0.5 mm for 7-11; 50 µm for 14-15; 100 µm for 5, 6, 12, 16; 200 µm for 13.

widened and flattened at base, usually decurrent. Setae 0.3-0.5 mm, straight, centrally attached. Capsules immersed to emergent, ca. 1 mm long, symmetric, short cylindric, slightly sulcate. Oper-

culum low conic, mamillate. Annulus of elongata-type. Peristome present, peristome teeth perforated and cleft, densely and highly papillose. Spores 11-14 µm. Calyptae mitrate.



SPECIMENS EXAMINED: **SIERIA: Altai Republic**, Chagan-Uzun River, 23.VII.1966, L.V.Bardunov (IRK).

Distribution. *Grimmia capillata* is known from southern part of Europe and in North Africa, Middle East, Iraq, and Turkmenistan. In Russia it was found only once by L.V.Bardunov in southeastern Altai Mts., in deserty steppe of Chuya River valley, on loamy soil among rock outcrops (this species was reported by Bardunov (1974) as *Schistidium plagiopodium* (Hedw.) Loeske).

Differentiation. *Grimmia capillata* is most close to *G. crinita* (species still not found in Russia) and is sometimes treated as its variety; the character differentiating *G. crinita* from *G. capillata* is sigmoid, excentrically attached setae (vs. straight, centrally attached in *G. capillata*). *Grimmia plagiopodia*, one more species with immersed peristome capsules and unistratose leaf laminae differs from *G. capillata* in sigmoid setae, ventricose capsules and shorter and non-decurrent hair-points in perichaetial leaves.

6. ***Grimmia donniana*** Sm., Engl. Bot. 18: 1259. 1804. Figs. 10, 11.

Plants in dense tufts or cushions, yellowish green above, brownish or blackish below, usually very hoary. Stems erect, 1-1.5 cm long, with central strand. Leaves flexuose and loosely appressed when dry, erect and patent when moist, 1.3-2.1×0.3-0.6 mm, from oblong base gradually tapering into

lanceolate acumen, widely keeled distally, blades forming 35-100° angle in distal part of leaf, not plicate; margins plane, never recurved; costa differentiated, strongly prominent dorsally, semi-circular in cross section, with 2 ventral epidermal cells; hyaline hair-points usually 0.5-1.0 mm long, in lower leaves shorter, in upper and perichaetial leaves longer, up to 1.5-2.0 mm, terete, in perichaetial leaves slightly widened and flattened basally, slightly denticulate to almost smooth, flexuose when dry; lamina unistratose near costa, bistratose at margins and with bistratose strips in distal 2/3 of leaf, upper and median laminal cells short rectangular mixed with subquadrate, gradually elongated to the leaf base, 10-20×9-11 µm, with moderately thickened sinuose walls, not bulging, basal juxta-costal cells elongate rectangular, 30-70×9-12 µm, with moderately thickened, not or slightly porose walls, basal marginal cells similar in shape and size, pellucid, uniformly thin-walled. Autoicous, androecia axillary or terminal, sporophytes usually present. Perichaetial leaves moderately larger than vegetative leaves, to 2.5×0.8 mm, with longer hair-points. Setae 1.5-2.5[3.0] mm, pale yellowish, straight. Capsules emergent to exserted, ovoid, 1.0-1.2 mm long, stramineous, exothelial cells thin-walled, stomata at urn base present. Operculum low conic, mamillate. Annulus of elongata-type. Peristome teeth orange, contrasting in color with the urn, entire or weakly perforated distally. Spores 9-11 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: **EUROPEAN RUSSIA: Murmansk Province**, Khibiny, 1981, L.Volkova (LE); Lapponia Imandrae, in monte Kivakkatunturi, 7.VIII.1883,

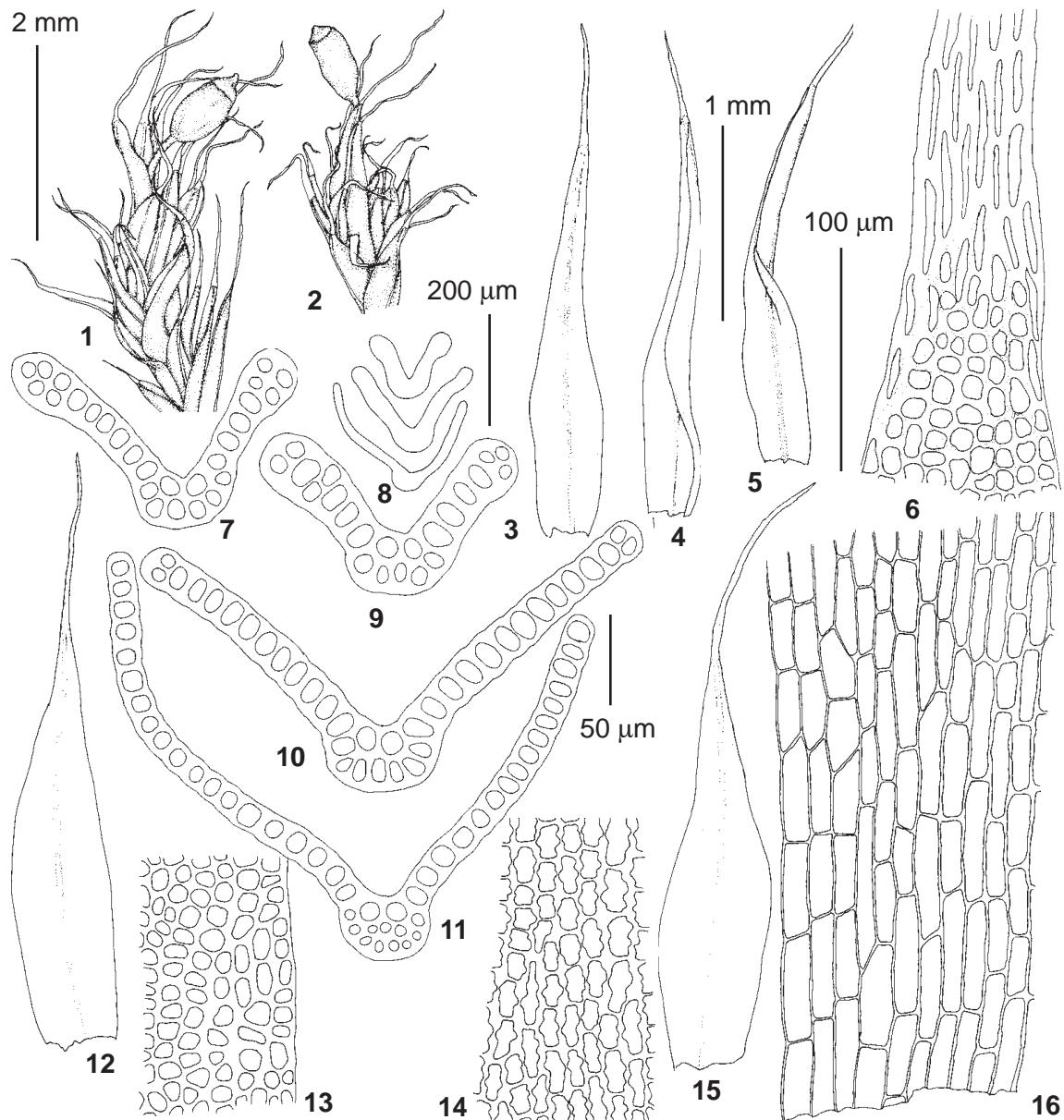


Fig. 11. *Grimmia donniana* Sm. (from Murmansk Province, 30.VIII.2001, E.Ignatova): 1-2 – habit; 3-5 – leaves; 6 – base of hair-point and upper leaf cells; 7-11 – leaf transverse sections; 12, 15 – perichaetial leaves; 13 – upper leaf cells; 14 – median leaf cells; 16 – basal leaf cells. Scale bars: 2 mm for 1-2; 1 mm for 3-5, 12, 15; 50 µm for 7, 9-11; 100 µm for 6, 13-14, 16; 200 µm for 8.

#381, V.F.Brotherus (LE); Khibiny Mts., Kunjok River, Pereval'nye Lakes, 2.IX.2001, Ignatova (MW); Takhtaryumchorr Mt., Molibdenovyj Cirque, 4.IX.2001, Ignatova (MW), 2.IX.1994, #123, 128, A.Yu.Likhachev (KPABG, MHA); Khibiny, Lovchorr, Botanikov Gorge, 5.VIII.1948, #1992a, R.N.Shlyakov (LE); Khibiny Mts., Ajkuajvenchjok Creek, 30.VIII.2001, Ignatova (MW); Lapponia Imandrae, in alpe Chibina, VII.1885, V.F.Brotherus (LE); Vudyavrchorr Mt., Botanicheskij Cirque, 31.VII.1998, Ignatov (MHA), 31.VIII.2001, Ignatova (MW); Khibiny Mts., Vudyavrchorr Mt., 26.VIII.2001, Ignatova (MW),

17.VII.1947, #44, #66, R.N.Shlyakov (LE), 17.IX.1946, #141, V.B.Kuvaev (MW); Khibiny Mts., between Bolshoj & Malyj Vudjavr Lakes, 6.IX.2001, Ignatova (MW); Khibiny, Kukisvumchorr, 16.VII.1948, #1809, R.N.Shlyakov (LE), 4-6.IX.2001, Ignatova (MW); Khibiny Mts., Petrelius Valley, 27.VIII.1932, #2/9, A.Korovin & A.Fomina (KPABG); Yukspor, 13.VII.1948, #1757, R.N.Shlyakov (LE); Yuksporlak pass, 30.VI.1948, #1608, R.N.Shlyakov (LE); Goltzovaya River, 29.VII.1988, #281, T. Dudoreva (KPABG); Lovozerskie Mts., Elmara-Jok Pass, 24.VIII.1982, #83/2, O.Belkina (KPABG); Karnasurt-Pyalkinchorr Pass,

30.VIII.1982, #127/5, O.Belkina & A.Likhachev (KPABG); Raslak Cirque, 26.VIII.1982, #109/3, O.Belkina & A.Likhachev (KPABG); Lavna-Tundra Mts., Lavnatundra Mt. 2.VII.1987, #101-2-87, O.Belkina (KPABG); Yumos Creek, 3.VIII.1987, #213-87, O.Belkina (KPABG); Karelia, Kivakkatunturi [Paanajarvi], VIII.1883, V.F.Brotherus (H); **CAUCASUS:** Kabardino-Balkaria, Elbrus Peak, 28.VII.2004, Ignatov & al. (MHA); **URALS:** Komi Republic, Kozhvinskij Distr., Lemva River, 21.IV.1956, I.D.Kil'dyshhevskij (LE); Nyadokota River, 21.IV.1956, I.D.Kil'dyshhevskij (LE); **SIBERIA:** Altai Republic, Kurkure Range, Kurkure-bazhi Peak, 13.VII.1976, N.Zolotukhin (MHA); Buryatia, South Baikal area, Tunkinskaya valley, Mondy village, 20.VI.1986, L.V.Bardunov (MHA); Djerginskij Reserve, 12.VII.2002, #37, D.Tubanova (UUH); Chita Province, Udogan Range, 9.VIII.1987 & 27.VII.1989, V.R.Filin (MW); Irkutsk Province, Vitim Reserve, Oron Lake, Labaznyj Creek, 4.VIII.1984, L.V.Bardunov (IRK, MW); Yakutia, Neryungri Distr., Khatyng River basin, Urga Creek, 18.VIII.1995, E.I.Ivanova (SASY, MW); Neryungri Distr., Udokan Range, 7.VIII.2000, L.V.Kuznetzova (SASY, MW); Tomponskij Distr., Suntar-Khayata, 13.VII.2003, Zolotov & Ivanova (MHA); **FAR EAST:** Chukotka, Provideniya Bay, 3.VIII.2001, 23.VIII.2001, O.M.Afonina (LE); Pekulnej Mt. Range, Televeem-First Creek, 22.VII.1979, O.M.Afonina (LE); Magadan Province, Ten'kinkij Distr., Sibit-Tyaeliakh, on rocks, 13.VIII.1976, L.Blagodatskikh (LE); Omsukchan, 15.VI.1959, S.Filatov (LE); Kamchatka, Elizovo Distr., Koryakskij Volkano, 26.VII.1985, Onipchenko (MHA).

Distribution. *Grimmia donniana* is known in Europe from Iceland and Great Britain to France and Italy, also in the Georgian Caucasus, in Asia in China and Japan, in North and South America. In Russia it is rather common in Kola Peninsula, especially in the Khibiny Mts. (the most frequent species of the genus in that area). It is sporadically found in other regions of the country: in Chukotka, Kamchatka, Magadan Province, central and southern Yakutia, Transbaikalia, a few collections from Altai Mts., the northernmost Urals, and only one locality in the Caucasus, in Kabardino-Balkaria (nival belt of Elbrus Mt.). It usually grows above the tree-line, in the alpine and nival belts up to 3800 m alt., mostly on rather dry acidic or neutral rocks.

Differentiation. *Grimmia donniana* can usually be recognized by small greish hoary cushions (as exception, muticous phenotypes occur), with numerous capsules, mamillate opercula, narrow lanceolate, widely keeled leaves with always plane margins, and uniformly thin-walled basal marginal cells (in vegetative leaves). The latter character is rather rare in Russian *Grimmia* species, known also in *G. incurva*, *G. fuscolutea* and *G. elongata*, that are unlike in general appearance, and in

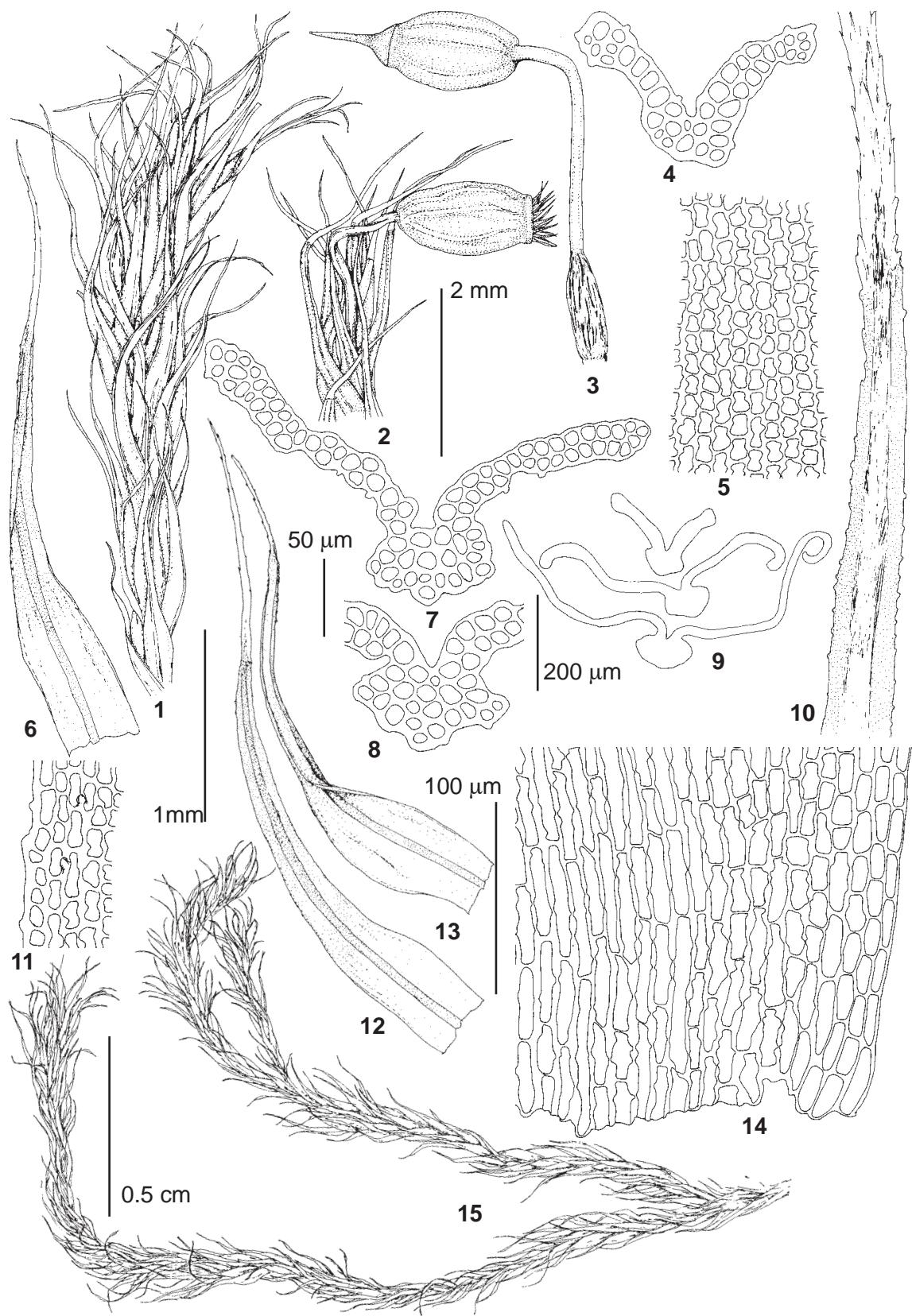
G. triformis. The differentiation of *G. donniana* from *G. reflexidens* and *G. triformis* is discussed under these species.

7. *Grimmia elatior* Bruch ex Bals.-Criv. et De Not., Mem. Reale Accad. Sci. Torino 40: 340. 1838. Figs. 12, 13.

Plants in large, loose, easily separating tufts or patches, dark green, yellowish green, or brownish green, moderately hoary. Stems erect or ascending, 2-7 cm long. Leaves erect or slightly flexuose, loosely appressed when dry, erect-spreading when moist, (2.5)-3-4(-5)×(0.5)-0.6-0.7(-0.9) mm, from oblong-ovate base gradually tapering into long acumen, longly acuminate, narrow at apical part, sharply keeled distally; margins plane to weakly recurved distally, more strongly recurved to revolute on one or both sides at proximal 1/2 of leaf; costa differentiated, strongly prominent dorsally, irregularly angled in cross section, 3-5-stratose, with 2 ventral epidermal cells; hyaline hair-points rather long in upper leaves, terete, moderately to weakly denticulate; lamina (1)-2-3-stratose in distal 2/3 of leaf, 3-5-stratose at margins; upper laminal cells rounded-quadrata to short rectangular, with moderately incrassate sinuose walls, 9-10 µm wide, opaque, with large low papillae, often moderately to strongly bulging; median laminal cells short rectangular, sinuose, basal juxta-costal cells elongate rectangular, with moderately incrassate, porose walls; basal marginal cells shorter, rectangular, pellucid, with transverse walls more thick than longitudinal walls. Dioicous, androecia terminal, sporophytes sporadic. Setae to 3 mm long, arcuate when moist. Capsules exserted, inclined to horizontal, ovoid, 0.7-2.0 mm long, ribbed. Operculum conic, with long erect beak. Annulus of affinis-type. Peristome teeth red, perforated and cleft. Spores 10-12 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:**

Murmanski Province, Khibiny Mts., Vudjavrchorr Mt., Yuzhnoe Skvoznoe Gorge, 30.VIII.1947, #RS-1473-47, R.N.Shlyakov (KPABG); Vudyavrchorr Mt., 30.VIII.1947, #1475, R.N.Shlyakov (LE); Khibiny Mts., Yukspor Mt., 30.VIII.1948, #1938, R.N.Shlyakov (LE); Lapponia or., Kantalaaks [Kandalaksha], VIII.1872, V.F.Brotherus (H); Salla, Kutsa, 1.VII.1939, A.Auer (H); Karelia, Soanlahti, Korpikallio, 1.VIII.1933, M.J.Kotilainen (H, LE); Soanlahti, Laaja, Vehkavaara, 14.XI.1936, A.J.Huuskonen (KPABG); Ruskeala, 23.VII.1936, A.J.Huuskonen (H); Suistamo, 20.V.1936, A.J.Huuskonen (H); Suisaari, 7.VII.1943, M.J.Kotilainen (H); Kurkijoki, 13.VI.1936, V.Rasanen & T.M.Laurila (H); Siikajarvi [Lahdenpohja], 11.VIII.1938, A.Pankakoski (H); Impilahti, Makisalo, 14.VI.1927, A.E.Koskimies (H); Pitkaranta Distr., Impilahti, 25-28.VI.1997, #754, 889, S.Huttunen & H.Wahlberg (H); Sortaval, 1.VII.1977, #1292, S.Huttunen & H.Wahlberg (H); Leningrad Province, Hogland, 23.VI.1867, M.Brenner (H); Pyhajarvi [near Priozersk], 30.VI.1904, H.Lindberg (H); Pskov Province, Porchov, 2.VIII.1917, N.Malta (H); **CAUCASUS:** Dagestan, Awarsk Distr., prope pag. Gimri, 24.V.1901, #12896, Th.Alexeenko (H-Br, LE); North Ossetia, North Ossetian



Reserve, VIII.1976, 19-21.VII.1977, 24-25.VII.1979, 27.VII.1980, *L.I.Abramova* (MW); pr. fl. Ardon, #245, *V.F.Brotherus* (H-SOL); **Kabardino-Balkaria**, Sovetskij Distr., Bezengi Gorge, 9.VIII.1988, #42, *Yu.L.Menitzkij & al.* (MHA); Elbrus area, Adyl-Su Creek, Dzhankuat glacier, X.1994, #50, *I.Pospelov* (MW); Adyl-Su Creek, 29.VII.2004, *Ignatov & al.* (MHA); Shkheda Creek, 29.VII.2004, *Ignatov & al.* (MHA); Baksan River at Adyl-Su Creek mouth, 30.VII.2004, *Ignatov & al.* (MHA); Cherek Bezengijskij River near Dumala Creek mouth, 31.VII.2004, *Ignatov & al.* (MHA); **Karachaevo-Cherkessia**, Aksaut Gorge, 13.VIII.1979, #10/14, *E.E.Gogina* (MHA); Teberda Reserve, Semen-Bash Mt., 6.VII.1976, 17.VIII.1987, *Onipchenko* (MHA); Alibek Gorge, 16.VIII.1986, *Ignatova* (MHA); Kel'bashi Mt., 12.VIII.1955, *A.L.Abramov & I.I.Abramov* (LE); Northern Klukhor Gorge, 11.IX.1994, #200/94, 3.IX.1998, #34/98 *Onipchenko* (MW); Klukhori, 1945, *I.Tumadzhanov* (LE); Shumka Gorge, 18.VII.1994, #88/94, 31.VII.1996, #200/96, *Onipchenko* (MW), 14.VIII.1986, *Ignatova* (MHA); Shumka waterfall, 14.VIII.1986, *Ignatova* (MHA); Gitche-Murudzhu Gorge, 2.VIII.1998, #z-46, *A.Volkov & S.Zenyakin* (MW); Murudzhu Gorge, 30.VI.1998, #4/98, *Onipchenko* (MW); Ullu-Murudzhu Gorge, 7-9.VIII.1986, *Ignatova* (MHA), 13.IX.1955, *I.Patrabolova* (LE); Baduk Gorge, 15.VIII.1986, *Ignatova* (MHA), 17.VIII.1993, #61/93, #65/93, *Onipchenko* (MW); Baduk Lakes, 26.VII.1955, *V.V.Makarov* (MHA); Goraly-Kol Gorge, 12-13.VIII.1986, *Ignatova* (MHA); Nazly-Kol Gorge, 10-11.VIII.1986, *Ignatova* (MHA); Bolshaja Khati para-Khadzhibej Pass, 17.VII.1994, #83/94, *Onipchenko* (MW); Bolshaja Khati para Gorge, 16.VII.1994, #78/94, *Onipchenko* (MW); Teberda River, 1.VIII.1986, *Ignatova* (MHA); Mukhu Gorge, 12.VII.1982, *E.L.Vaulina* (MHA); Kyshkadzher Gorge, 10.VII.1994, #38/94, *Onipchenko* (MW); Azgek Gorge, 18.VIII.1955, *V.V.Skripchinskij* (MHA); Bolshaya Laba River upper course, 4.VIII.1946, #25, *Petrovicheva* (LE, MW); **Stavropol Territory**, Pyatigorsk, Beshtau Mt., 29.V.1891 (LE); **Krasnodar Territory**, Kuban' Distr., Uspenskaya st., Novopokrovsk forestry, 3.VII.1926, *E.Shiffers & L.Sokolova* (LE); Sochi Distr., Khosta, 18.VIII.1935, *L.N.Vasil'eva* (LE); Urushent River basin, Alous Mt., 13-14.VIII.1994, *T.Akatova* (CSR, MHA); Malaya Laba River basin, Tryu-Yatyrgvarta Mts., 16.VII.1997, *T.Akatova* (CSR, MHA); Malaya Laba River basin, Basskany Ridge, 22.VII.1998, *T.Akatova* (MHA); Armovka Mt., 19.VI.2000, *T.Akatova* (CSR, MHA); **Adygeya**, Belya River basin, Oshten Mt., 30.VII.1997, *T.Akatova* (CSR); **URALS: Komi Republic**, Pechora Reseve, 25.VIII.1935, *A.Leont'ev* (LE); **Perm Province**, Basegi Reserve, Southern Baseg, 9.VI.1992, #97, *A.Bezgodov* (MW); Basegi Reserve, Middle Baseg, 21.VI.1985, #328, *A.Bezgodov* (MW); Vishera Reserve, Kuryksar Range, 23.VI.1995, #321, 357, 346, *A.Bezgodov & A.Selivanov* (MW); Olkhovochnyj Range, 16.VII.1994, #481, *A.Bezgodov* (MW); Olkhovka Creek, 26.VI.1994, #140, *A.Bezgodov* (MW); **Sverdlovsk Province**, Konzhakovskij Kamen Mt., 10.VII.1953, #5, *P.L.Gorchakovskij* (LE, MW); **Bashkortostan**, Baimak Distr., Irrendyk Range, Mukasovo, Gadelsha waterfall, 17.VI.1989, #54, *A.I.Solomeshch* (MHA); Beloretsk Distr., Bretyak, 12.IX.1990, #13/14, *Ignatova* (MHA); **Chelyabinsk Province**, Zlatoust Distr., Urenga Range, Golaya Mt., 9.VII.1990, #199b, *A.A.Muldashev* (MHA); **SIBERIA: Altai Republic**, between Bortuldag & Kair Creeks, 25.VII.1908, *P.Krylov* (H-Br, LE); Shebalino, 6.VII.1909, *P.Kursky* (H-Br); Amoss, 27.VI.1909, *P.Kursky* (H-Br); ad pag. Sentelekskaja, 4.VII.1913, *N.Kusnezow* (H-Br); Ridderz, VIII.1919, *Vereshchagin* (H-Br); Ak-Turu River, 17.VII.1966, *L.V.Bardunov* (IRK); Ust-Nezi Village, 22.VII.1953, *V.Melnichuk* (MHA); Tabozhok Peak, 1.VIII.1992, #31/5 & 30.VII.1992, #31/16, *Ignatov* (MHA); Tabozhok Creek, 1-4.VIII.1992, #31/17, #32/8, #33/11, 21.VII.1993, #36/363, *Ignatov* (MHA); Katanda, 20.VI.1966, *L.V.Bardunov* (IRK); Ak-Turu, 18.VII.1966, *L.V.Bardunov* (IRK); Tyuguryuk, 23.VI.1966, *L.V.Bardunov* (IRK); Bogoyash Creek in upper course, 27.VII.1993, #36/331, 36/341, 36/98, *Ignatov* (MHA); Malyj Yaloman, 30.VII.1991, #25/2, *Ignatov* (MHA); Karakem River Basin, Kobiguayuk Creek, 14-15.VI.1989, #0/469, #0/948, #0/729, *Ignatov* (MHA); Ayulyuyuzuk Creek, 16.VI.1989, #0/468, *Ignatov* (MHA); Chiket-Aman pass, 28.VII.1966, *L.V.Bardunov* (IRK); Seminskij Pass, 15.VI.1972, #176, *N.Alyanskaya & al.* (MHA); Seminskij pass, 15.VI.1966, *L.V.Bardunov* (IRK); Kurkure Range, Kayakkatuyarykskij Creek, 6.VI.1991, #4/11, #8/331, #8/324, #3/200, #3/46, #3/13, #7/106, #7/97, #7/102, #7/42, #8/82, #8/169, #8/170, #8/48, 28.VII.1991, #6/25, *Ignatov* (MHA); Kayak Lake, 30.VI.1991, #7/187, *Ignatov* (MHA); Teletzkoe Lake, Artsyshu Creek, 8.IX.1987, *N.I.Zolotukhin* (MHA); Chulcha River, Nepristupnyj waterfall, 10.VII.1991, #9/104, *Ignatov* (MHA); Chinairu Creek (Aedigan Tributary), 8.VII.1993, #34/102, #34/139, #34/201, *Ignatov & Ignatova* (MHA); Shebalino Distr., Tamanel Peak, 6.VI.1993, #34/185, *Ignatov & Ignatova* (MHA); Kurkure Range, Altintash Creek, 7.VI.1982, *N.Zolotukhin* (MHA); Kaira Creek near Kairabazhi Peak, 14.VII.1991, #13/37, *Ignatov* (MHA); Kyga River basin, Bayas Lake, 2.VII.1989, #0/467, *Ignatov* (MHA); Shebalino Distr., Askat village, #1066A, *V.A.Manakyan* (IBA); Teletzkoe Lake, Karagaj Creek, 10.VIII.1988, *N.I.Zolotukhin* (MHA); Chemal, 14.VI.1966, *L.V.Bardunov* (IRK); Chemal, 5.VIII.1991, #29/6, *Ignatov & Ignatova* (MHA); Ust-Sema, #B-65184, *T.S.Elias & al.* (NY); Teletzkoe Lake, Yailyu, #21/33, 1.VI.1989, *Ignatov* (MW); Teletzkoe Lake, Yurga, Azhi cape, 24.VII.1991, *N.I.Zolotukhin* (MHA); Kamga River basin, Srednij Shaltan Creek, 6.VI.1989, #0/905, *Ignatov* (MHA); **Krasnoyarsk Territory**, Taimyr, Taimyr Lake, Ledyanaya Bay, 11-17.VII.2004 & 12.VIII.2004, #G2, G4, G6-9, G12-15, G18, G20, *V.Fedorov* (MW); Putoran Plateau, Agatskij Kamen Mt., 7.VII.1968, #22, *V.Kuvaev* (MW); Putoran Plateau, Kapchuk Lake, 25.VII.1982, #96, *I.V.Czernyadjeva* (LE); Baikit Distr., Central Siberian Reserve, Stolbovaya, 27.VI.1992, #46, *S.Shcherbina* (MW); Kochumdeki River, 6.VIII.1991, *S.Shcherbina* (MW); NW part of East Sayan Range, «Stolby» State Reserve, 26.V.1996, *T.N.Otnyukova* (KRF, MW); Western Sayan Mts., Malyj On River, 5.VII.1968, *L.V.Bardunov* (IRK); Minussinsk, VIII.1880, *N.Martianoff* (H-Br); Montes Sajanensis, in monte Borus, VIII.1888, *Argunoff* (H-Br); **Tyva Republic**, Todginskaya Valley, west extremity of Kadyshev Lake, 30.VIII.1999, *T.N.Otnyukova* (KRF, MW); **Irkutsk Province**, Kamar-Daban Mt. Range, Murino, 27.VII.1957, *L.V.Bardunov* (IRK); Vitimskij Reserve, Amalyk Creek, 9.VIII.1984, *L.V.Bardunov* (IRK); Vitimskij Reserve, Vitim River at Amalyk Creek mouth,

Fig. 12. *Grimmia elatior* Bruch ex Bals.-Criv et De Not. (1, 4-15 – from Perm Province, A.Bezgodov, #140; 2-3 – from North Ossetia, VIII.1976, *L.I.Abramova*): 1, 15 – habit; 2-3 – capsules; 4, 7-9 – leaf transverse sections; 5 – median leaf cells; 6, 12-13 – leaves; 10 – base of hair-point and upper leaf lamina; 11 – upper leaf cells; 14 – basal leaf cells. Scale bars: 0.5 cm for 15; 2 mm for 1-3; 1 mm for 6, 12-13; 50 µm for 4, 7-8; 100 µm for 5, 11, 14; 200 µm for 9, 10.

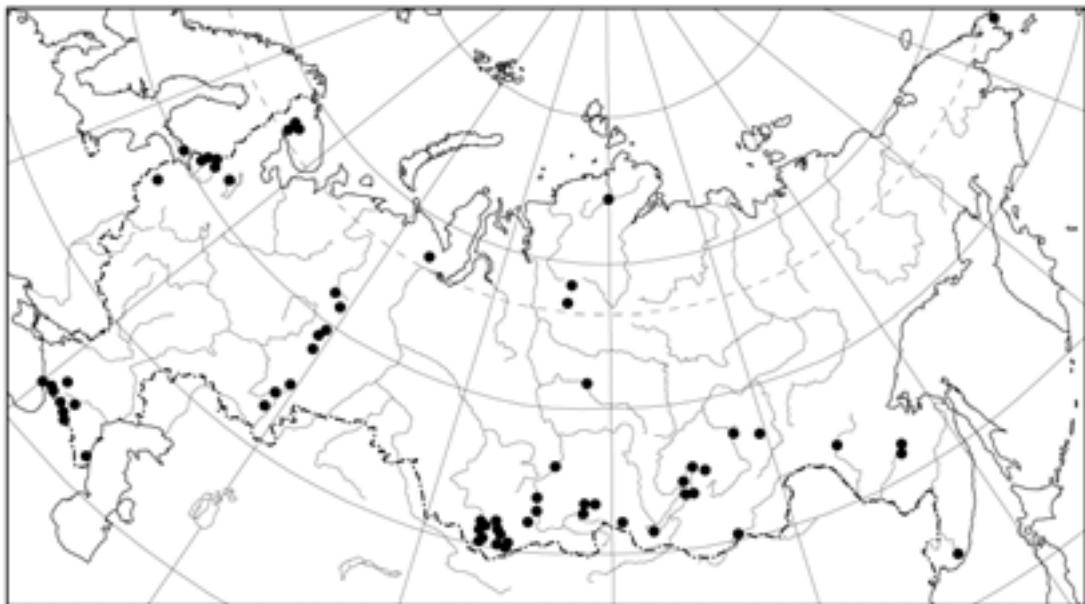


Fig. 13. Distribution of *Grimmia elatior* Bruch ex Bals.-Criv et De Not. in Russia

24.VI.1984, L.V.Bardunov (IRK); **Buryatia**: Eastern Sayan Mts., Kitoj River, 12.VIII.1960, L.V.Bardunov (IRK); Eastern Sayan Mts., Kadyr-Oruk pass, 19.VII.1961, L.V.Bardunov (IRK); Eastern Sayan Mts., Kara-Buren' River, 12.VII.1961, L.V.Bardunov (IRK); NE Baikal, Ushkanji islands, 27.VI.1956, L.V.Bardunov (IRK); NE Baikal, Bolshaya Cheremshanaya Creek middle course, 24.VII.1956, L.V.Bardunov (IRK); NW Baikal, Kovrizhka cape, 27.VIII.1957, L.V.Bardunov (IRK); NW Baikal, Bolsolej bay, 25.VIII.1967, L.V.Bardunov (IRK); NE Baikal, Turali cape, 26.VIII.1956, L.V.Bardunov (IRK); Dzherginskij Reserve, 22.VII.2000, #3, D.Tubanova (UU); **Chita Province**, union of Ili Creek with Onon River, pr. Duldurga, P.Michno (LE); **FAR EAST**: **Khabarovsk Territory**, Verkhnebureinskij Distr., Tastakh Creek mouth, 7.VIII.1997, #97-1111, Ignatov (MHA); Bureinkij Reserve, Pravaya Bureya River, 27.VIII.1997, #97-1108, 97-1110, Ignatov (MHA); **Amurskaya Province**, Upper Zeya Plane, Zhurban village, 30.VI.1974, S.K.Gambaryan (MHA); **Primorskij Territory**, Chuguevka Distr., Oblachnaya Mt., 31.VII.1980, V.Ya.Cherdantseva (VLA); **Chukotka**, Lavrentij Bay, Krauze Cap, 29.VIII.1975, O.M.Afonina (LE).

Distribution. *Grimmia elatior* is widespread in Europe, Transcaucasia and Turkey, known from Central and Eastern Asia, North America, and also from Madagascar. In Russia it is more common in the Caucasus and Altai Mts., and not rare in South and Middle Urals, Kola Peninsula and Karelia. It is scattered in Taymyr, Putorana Plateau, Chukotka, Eastern Sayan Mts., Transbaikalia, Amurskaya Province and Khabarovsk Territory, and only one locality is known from the Primorskij Territory. It grows in a wide elevation range, from sea level to 3100 m alt., in the forest and alpine belts, mostly on siliceous rocks, either shaded or exposed.

Differentiation. *Grimmia elatior* is usually easy to recognize by its large size, leaves longer than 2.5 mm, lamina bistratose to 3-5-stratose at margins in the distal part of the leaf, upper laminal cells papillose, and costa strongly prominent, furrowed, and irregularly angled dorsally in cross section. The differentiation from *G. muehlenbeckii* and *G. jacutica* is discussed under these species.

9. *Grimmia elongata* Kaulf. in Sturm., Deutschl. Fl. Abtheilung II, Cryptogamie 4(13):24. 1812. Figs. 10, 14.

Plants in compact cushions, fragile, dark green or blackish green above, brownish or blackish below. Stems erect or ascending, 2-3 cm long, fasciculately branching, evenly foliated, with weak central strand. Leaves slightly flexuose or contorted, loosely appressed when dry, with appressed base and spreading acumen when moist, 1.2-1.6[2.0]×0.3-0.5 mm, lanceolate, sharply and narrowly keeled distally, blades forming <40° angle; margins plane in distal part of leaf, recurved on one or both sides in proximal part; costa differentiated, strongly prominent dorsally, semi-circular in cross section, with 2 ventral epidermal cells; hyaline hair-points absent to very short, not longer than 0.3 mm (usually less than 0.1 mm); lamina mostly unistratose at distal part, bistratose in 1-2 cell rows at margins; upper laminal cells oblate, subquadrate to short rectangular, 7-9 µm, thick-walled, moderately sinuose, with brownish cell walls, median laminal cells short rectangular, 10-18×8-10 µm, with strongly sinuose walls, basal

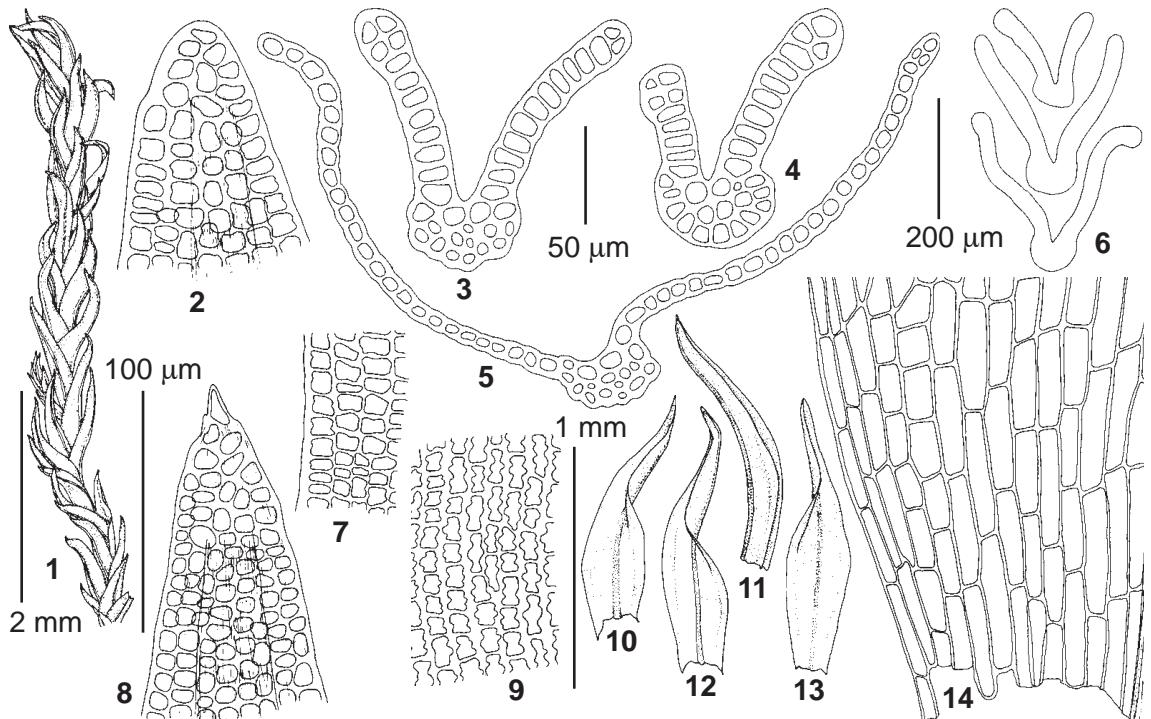


Fig. 14. *Grimmia elongata* Kaulf. (from Tyumen Province, V.B.Kuvaev, #508): 1 – habit; 2, 7-8 – upper leaf cells; 3-6 – leaf transverse sections; 9 – median leaf cells; 10-13 – leaves; 14 – basal leaf cells. Scale bars: 2 mm for 1; 1 mm for 10-13; 50 µm for 3-5; 100 µm for 2, 7-9, 14; 200 µm for 6.

juxtapostial cells elongate rectangular, 25-45×9-11 µm, with slightly thickened, not porose walls, basal marginal cells similar in shape and size or shorter, with uniformly thin walls. Dioicous, androecia terminal, sporophytes sporadic, but both specimens from Russia lacking capsules (one of them with androecia). [Perichaetial leaves similar to vegetative leaves, but with widened base. Setae 1.5-2.5 mm, yellowish, straight when wet. Capsules emergent to exserted, ovoid, 0.6-1.0 mm long, smooth; exothelial cells thin-walled, stomata at urn base present. Operculum conic, with short obtuse beak. Annulus of elongata-type. Peristome teeth entire. Spores 11-13 µm. Calyptrae mitrate, seldom cucullate].

SPECIMENS EXAMINED: **SIBERIA:** Tyumen Province, Beryezov Distr., Khulga River basin, #508, V.B.Kuvaev (LE, MW); Sosva, Porna-ja-Marja, 20.VII.1915, B.N.Gorodkov (H-Br, #1829009).

Distribution. *Grimmia elongata* is known in Europe from Scandinavia (but not found in Finland) and Great Britain to Spain and Italy, eastward to Romania and Poland, Africa (Lesotho and Uganda), Asia (India, China, and Japan), South and Central America; in Caucasus it was collected in Georgia. In Russia it is known only from two close localities, both in the eastern slope of Polar Urals. It grows at 500 m alt., above tree-line, on acidic rocks.

In the annotation to *Grimmia elongata* in Handbook of acrocarpous mosses of the USSR (Savicz-Lyubitzkaya, Smirnova, 1970) this species is characterized as rare montane plant in Carpathians, Urals, Siberia, and Middle Asia, and in the Check-list of mosses of the former USSR (Ignatov & Afonina, 1992) it is reported for European and Beringian Arctic, Caucasus, southern Siberia, and Far East. Most of these records are based on erroneously identified specimens (as seen from herbaria material). East Siberian records (Nyholm, 1998; Muñoz & Pando, 2000) are also based on wrongly identified specimen (in valle flum. Lena, Bulun, H.Nilsson-Ehle (H)), representing another genus, *Schistidium*.

Differentiation. Superficially *G. elongata* is most similar to alpine forms of *G. incurva* also growing in Urals; both species share uniformly thin-walled basal marginal cells, proximally recurved leaf margins, and very short hyaline hair-points. However, the leaves of *G. incurva* are longer, with length to width ratio 5-6:1 (3-4:1 in *G. elongata*), walls of distal laminal cells are not very sinuose and are not brownish-colored (as in *G. elongata*),

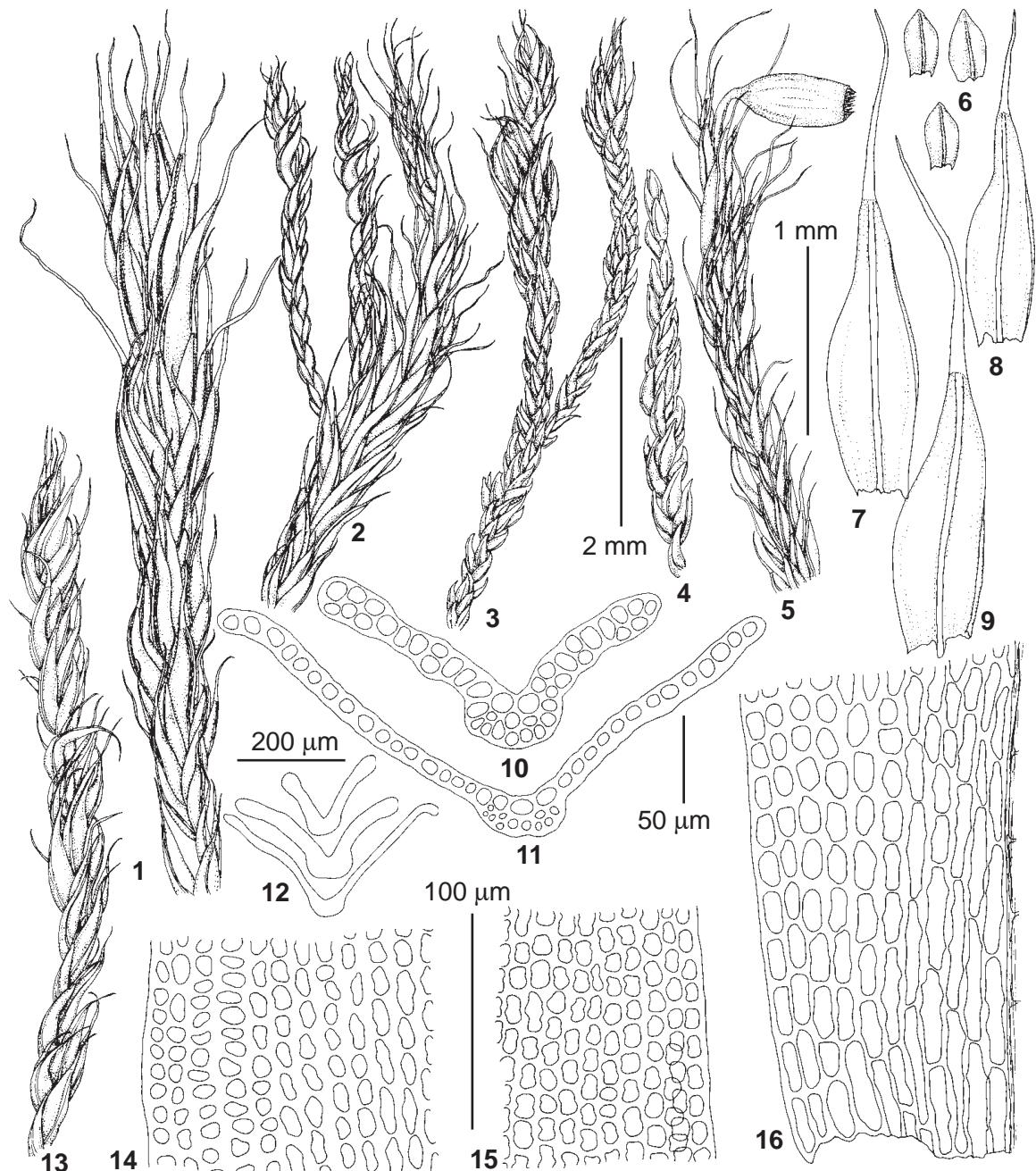


Fig. 15. *Grimmia funalis* (Schwaegr.) B.S.G. (1,4,15 – from Karachaevo-Cherkessia, V.Onipchenko, #15/97; 2 – from Krasnoyarsk Territory, 5.VII.1968, L.V.Bardunov; 3 – from Murmansk Province, R.N.Schlyakov, #2124; 5 – from Altai #0/908, Ignatov; 6-14, 16-18 – from Yekaterinburg Province, P.L.Gorchakovskij, #18): 1-5, 13 – habit (4 – small thread-like shoot); 6 – leaves from thread-like shoot; 7-9 – leaves; 10-12 – leaf transverse sections; 14 – upper leaf cells; 15 – median leaf cells; 16 – basal leaf cells. Scale bars: 2 mm for 1-5, 13; 1 mm for 6-9; 50 µm for 10-11; 100 µm for 14-16; 200 µm for 12.

basal juxtacostal cells are thick-walled, strongly porose (vs. thin-walled and eporose), and leaves distally are more widely keeled to flat due to broadened costa (vs. narrowly and sharply keeled in *G. elongata*). Brownish color, sharply and narrowly keeled leaves, uniformly

thin-walled basal marginal cells, and margins recurved proximally are characteristic also for *G. fuscolutea*, known in Russia by few collections from southern Siberia and a single one from Caucasus. This species differs from *G. elongata* by long hyaline hair-points, usually

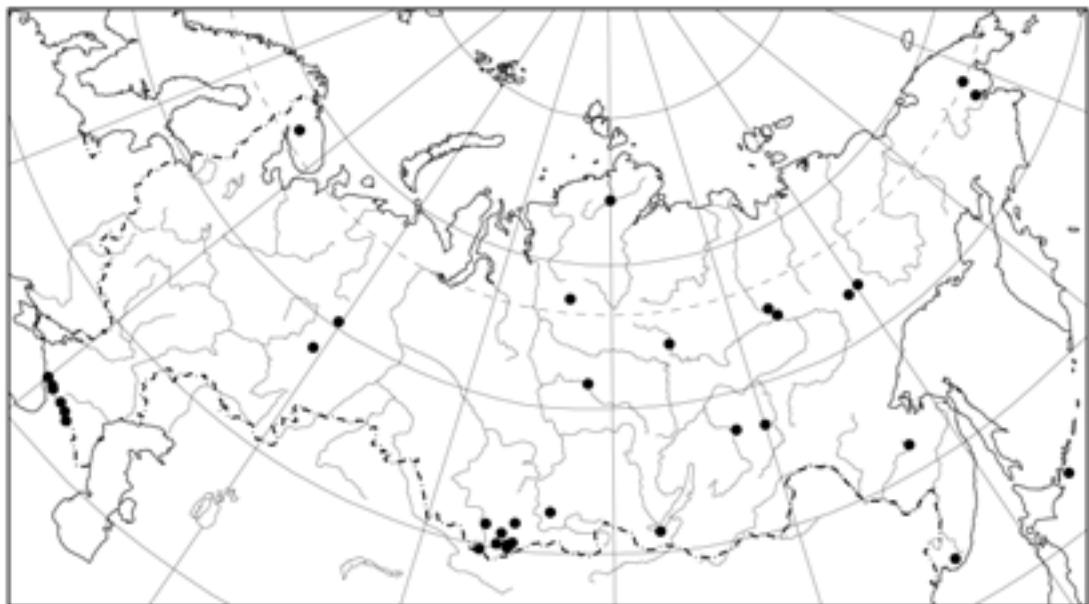


Fig. 16. Distribution of *Grimmia funalis* (Schwaegr.) B.S.G. in Russia

longer than 0.3 mm (very short in *G. elongata*), setae curved when moist (straight in *G. elongata*), slightly furrowed capsules (smooth in *G. elongata*), and autoicous plants with androecia hidden just below perichaetia (dioicous plants and terminal androecia in *G. elongata*). One of Urals specimens of *G. elongata* was tentatively identified in herbarium as *G. donniana*, which is also similar to *G. elongata* in uniformly thin-walled basal marginal cells, but differs in yellowish color, long hyaline hair-points and hoary cushions, widely keeled leaves and margins always plane throughout.

9. *Grimmia funalis* (Schwaegr.) B. S. G., Bryol. Europ. 3: 119, tab. 247. 1845. — *Trichostomum funale* Schwaegr., Sp. Musc. Frond., Suppl. 1(1): 150, tab. 37. 1811. — *Grimmia funalis* var. *calvescens* (Kindb.) H. Möller, Ark. Bot. 26A (2): 65. 1934. — *Grimmia calvescens* Kindb., Christiania Vidensk.-Selsk. Forh. 1888(6): 19. 1888. Figs. 15, 16.

Plants in dense or loose, easily separating tufts, yellowish green or graish green. Stems erect, 2-3 cm long, thin thread-like shoots with small scaly leaves often present inside the tuft. Leaves spirally twisted when dry, (1.0-)1.5-2.0×(0.3-)0.4-0.6 mm, lanceolate, keeled distally; margins plane or slightly recurved on one side in middle part of leaf; costa differentiated, prominent dorsally, semi-circular in cross section, with 2(-3) ventral epidermal cells;

hyaline hair-points short or long, weakly denticulate or almost smooth; lamina partially bistratose in distal 2/3, unistratose at base; upper and median laminal cells 8-12 µm wide, isodiametric to short rectangular, with strongly thickened and moderately sinuose walls, cell areolation looking homogenous in distal 2/3 of lamina; basal juxta-costal cells elongate rectangular, porose, basal marginal cells shorter, with moderately thick longitudinal walls and strongly thick transverse walls. Dioicous, sporophytes very rare in the territory of Russia (known from southern Siberia). Setae 1.5-2 mm, arcuate when moist. Capsules emergent, ovoid, smooth or slightly furrowed. Operculum conic, shortly rostrate. Annulus of elongata-type. Peristome teeth orange, split distally, papillose. Spores 15-17 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:**

Murmansk Province, ad. fl. Kurengi, 1861, N.-I. Fellman (H); Khibiny Mts., Koashva Mt., 21.VIII.1949, #1604, R.N. Shlyakov (KPABG); Lovchorr, Botanikov Gorge, 12.VIII.1928, #2124, 1992, R.N. Shlyakov (LE); Lovchorr, 5.VIII.1948, #1992b, R.N. Schljakov (LE); Ajkuajvencjhok Gorge, 16.IX.1989, O.M. Afonina (KPABG); Vudjavrchorr Mt., Yuzhnoe Skvoznoe Gorge, 30.VIII.1947, #RS-1472-47, R.N. Shlyakov (KPABG); Yukspor Creek, 13.VII.1948, 21.VIII.1949, #1756, 2440, R.N. Shlyakov (KPABG); Kukisjok Creek, 29.VI.1990, Ignatov (MHA); **CAUCASUS:** **Kabardino-Balkaria**, Bezengi Gorge, 9.VIII.1988, #42, Yu. Menitzkij & al. (MHA); Cherek Bezengijskij River, Dumala Creek, 31.VII.2004, Ignatov & al., (MHA); Elbrus Mt., VIII.1975, T. Davydkina & E. Seman (LE); Elbrus area, Adyl-Su Creek, Dzhankuat Glacier, X.1994, #31, #46, I. Pospelov (MW); **North Ossetia**, Lars, #126, A.H. & V.F. Brotherus (H-SOL); North Ossetian Reserve, 19.VII.1976, #20, L.I. Abramova (MW); **Karachaevo-**

Cherkessia, Kuban, in summo jugo alpino inter Do-Ut et Utschkulan, 3.IX.1890, *S.Sommier & E.Levier* (H); Teberda Reserve, Alibek Gorge, 4.VII.1995, #18/95, *Onipchenko* (MW); Northern Klukhor Gorge, 8.IX.1994, #178/94, *Onipchenko* (MW); Oriuchat Gorge, 4.IX.1994, #152/94, #165/94, *Onipchenko* (MW); Buulgen-Klukhor Pass, 29.VIII.1997, #15/97, *Onipchenko* (MW); Amanauz River left bank, 23.VIII.1955, *A.L.Abramova & I.I.Abramov* (LE); Shumka Gorge, 31.VIII.1996, #199/96, 205/96, *Onipchenko* (MW); Murudzhu Gorge, 1.VII.1998, #7/98, 24.IX.2003, #24/03, *Onipchenko* (MW); Ullu-Murudzhu Gorge, 8.VIII.1986, *Ignatova* (MW); Goralykol Gorge, 21.VII.1994, #111/94, *Onipchenko* (MW); Bolshaya Khati para, 17.VII.1994, #84/94, #85/94, *Onipchenko* (MW); Bolshaya Khati para-Khadzhibej pass, 17.VII.1994, #85/94, *Onipchenko* (MW); Azgek Gorge, 17.VIII.1985, 30.VII.1993, #35/93 *Onipchenko* (MHA, MW); Khati para Ridge, 29.VII.1993, #31/93, *Onipchenko* (MW); Malaya Khati para Gorge, 6.VII.1994, #9/94, 27.VII.1994, 117/94, 5.VIII.1995, 15/95, *Onipchenko* (MW), 4.VIII.1986, *Ignatova* (MHA); Kyshkadzher Gorge, 10.VII.1994, #28/94, *Onipchenko* (MW); Bolshoy Zelenchuk River basin, Pshish Mt., 5.VIII.1990, *T.Akatova* (CSR); **Krasnodar Territory**, Caucasian Reserve, Abago Mt., 14.VII.1986, *T.Akatova* (CSR); Urushten River basin, Alous Mts., 13.VIII.1994, *T.Akatova* (CSR, MHA); Tryu-Yatyrgvarta Mts., 20.VII.1997, *T.Akatova* (CSR, MHA); **Adygeya**, Belaya River basin, Abago Mt., 15.VII.1986, *T.Akatova* (CSR, MHA); **URALS**: **Sverdlovsk Province**, Serebryanskij Mt. Range, 12.VII.1953, #18, *P.L.Gorchakovskij* (LE, MW); Denezhkin Kamen Mt. Range, 26.VII.1996, A.P.Djachenko (SVER); **SIBERIA: Altai Republic**, inter fl. Bortuldag et Kair, 25.VII.1903, *P.Krylov* (H-Br); Bobyrgan, 16.VI.1903, *P.Krylov* (H-Br); Terekhta jugum, 3.VIII.1909, *P.Kursky* (H-Br); Ak-Turu, 18.VII.1966, *L.V.Bardunov* (IRK); Tabozhok Peak, 1.VIII.1992, #31/76, *Ignatov* (MHA); Kokkul Lake, 4.VIII.1992, #33/12, *Ignatov* (MHA); Malaya Kokorya Creek, 21.VI.1993, #36/344, *Ignatov* (MHA); Dvukhkarovaya Creek, 25.VII.1993, #36/179, *Ignatov* (MHA); Bogoyash Creek, 27.VI.1993, #36/135, 36/335, *Ignatov* (MHA); Karakem River, 18.VI.1989, #0/469, 0/470, 0/908, 0/909, 0/911, 0/912, 0/914, 0/915, 0/916, 0/297, *Ignatov* (MHA); Kayakkatuyarykskij Creek, 27-28.VI.1991, #3/112, 3/165, 3/52, 3/107, 3/33, 3/69, 6/18, *Ignatov* (MHA); Kayak Lake, 30.VI.1991, #7/182, 7/5, 7/7, 7/35, *Ignatov* (MHA); Kayra Creek near Kayra-bazhi Peak, 14.VI.1991, #13/30, 13/45, 13/38, *Ignatov* (MHA); between Kaira-bazhi Peak and Bardaky Lake, 14.VII.1991, #13/133, *Ignatov* (MHA); Kolyushta Mt., 30.VI.1989, #0/94, *Ignatov* (MHA); Bayas Creek, 2.VI.1989, #0/913, *Ignatov* (MHA); Karakol Lakes, 3.VIII.1991, #28/121, *Ignatov & Ignatova* (MHA); Katunskij Range, Ioldo River, 23.VII.2000, *O.Pisarenko* (MW); **Krasnoyarsk Territory**, Taimyr, Taimyr Lake, Ledyanaya Bay, 22.VII.2004, #G3, *V.Fedosov* (MW); Putorana Plateau, Agatskij Kamen Mt., 7.VII.1968, #1, 22, *V.Kuvaev* (MW); Putorana Plateau, Nyakshingda Lake, #82, 87, 412, *V.B.Kuvaev* (MW); Baikit Distr., Selnin Creek, 17.VII.1990, #240, *S.Shcherbina* (MW); Western Sayan Mts., Malyj On Creek, 5.VII.1968, *L.V.Bardunov* (IRK); Olenjya Rechka, 19.VI.1968, *Bardunov & Stezko* (IRK); **Buryatia**, Khamar-Daban Ridge, Baikalskij Reserve, Nemskij Klyuch Creek, 9.VIII.2001, *N.A.Konstantinova* (MW); **Irkutsk Province**, Vitim Reserve, Oron Lake, Kultuchnaya Creek, 28.VI.1984, *L.V.Bardunov* (IRK, MW); **Yakutia**,

Suntar Distr., Vilyuj River, 25.VII.1958, #53/1, *Kildyushhevskij* (MW); Neryungri Distr., Udokan Range, 29.VII.2000, *L.V.Kuznetzova* (SASY, MW); Tomponskij Distr., Suntar-Khayata Range, Kyubyume Creek, 16.VI.1999, *E.I.Ivanova & K.K.Krivoshapkin* (SASY, MW); Tomponskij Distr., Suntar-Khayata Range, Krasnoe Lake, 10.VII.2003, *E.I.Ivanova & V.I.Zolotov* (SASY, MW); Kobyajskij Distr., Kitchan Settlement, 3.VII.2002, *E.I.Ivanova* (SASY, MW); Kobyajskij Distr., Lyampushka River, 15.VII.2002, *E.I.Ivanova* (SASY, MW); **FAR EAST**: **Khabarovsk Territory**, Bureinskij Reserve, Levaya Bureya-Kurajgagna, 8.VIII.1992, *B.Borisov* (MW); Medvezh'ye Lake, 9-13.VIII.1997, #97-1099, #97-1094, *Ignatov* (MHA), #60196a, *Z.Iwatsuki* (MHA) & #97-234, *B.C.Tan* (FH); **Primorskij Territory**, Alekseevskij Range, Ol'khovaya Mt., 8.VIII.1986, *V.Barkalov* (VLA); **Kamchatka Province**, Shikotan Island, Gorobetz Bay, 30.VIII.1978, *V.Ya.Cherdantseva* (VLA); **Chukotka**, Velikaya River, Tavatvaam Creek, 29.VIII.1983, *O.M.Afonina* (LE, MW); Tanyurer River, Golubaya Creek, 14.VII.1981, *O.M.Afonina* (LE, MW).

Distribution. *Grimmia funalis* is widespread in mountain areas of the Holarctic, it is known from most European countries (including Great Britain and Iceland), Algeria, Madeira and Canarian Islands, Turkey, Middle Asia, Mongolia, China, North America and Greenland. In Russia *G. funalis* is not rare in Kola Peninsula, Caucasus, and Altai, scattered in Putorana Plateau, Western Sayan Mts., Buryatia, Yakutia, Khabarovsk and Primorskij Territory, and it was only found twice in the alpine belt of North Urals. Grows at all altitudes, but more frequently at 1900-3100 alt., on acidic and neutral rocks.

Differentiation. *Grimmia funalis* can be recognized by usually spirally twisted leaves (it is better seen on thread-like thin shoots with scaly leaves lacking hair-points which are often found in tufts) and homogenous cell areolation (cells uniform in size and shape, thick-walled, sinuose).

10. *Grimmia fuscolutea* Hook., Musci Exot. 1: 63. 1818. — *Grimmia apiculata* Hornsch., Flora 2(2): 442. 1819, nom. illeg. Figs. 17, 18.

Plants in dense tufts, yellowish green above, blackish brown below, sometimes brownish throughout. Stem ascending to erect, 1-2 cm long, fasciculately branched, densely foliated. Leaves slightly flexuose, loosely appressed when dry, appressed at base and with spreading acumens when wet, narrow lanceolate, 1.4-1.6(-2.0)×0.3-0.4(-0.5) mm, acuminate, sharply keeled distally, blades forming < 40° angle; margins plane in distal part of leaf, narrowly recurved to revolute on one or both sides below; costa differentiated, strongly

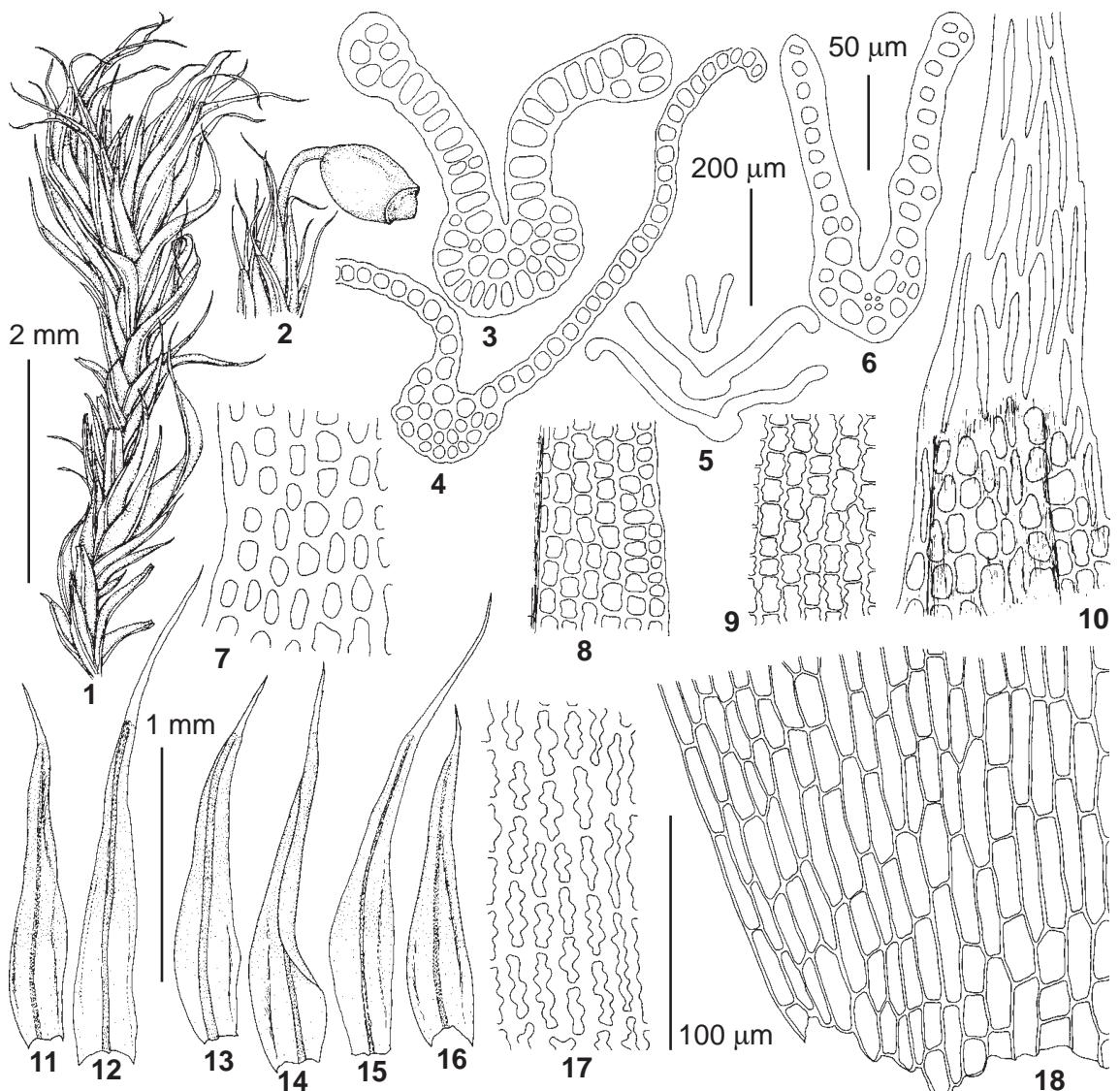


Fig. 17. *Grimmia fuscolutea* Hook. (1, 3-5, 8-16, 18 – from Altai Republic, M.Ignatov, #0/476; 2, 6-7, 17 – from Karachaevo-Cherkessia, V.Onipchenko, #95/94): 1 – habit; 2 – capsule; 3-6 – leaf transverse sections; 7-8 – upper leaf cells; 9, 17 – median leaf cells; 10 – base of hair-point and upper leaf cells; 11-16 – leaves; 18 – basal leaf cells. Scale bars: 2 mm for 1-2; 1 mm for 11-16; 50 µm for 3-4, 6; 100 µm for 7-10, 17-18; 200 µm for 5.

prominent dorsally, semi-circular in cross section, with 2 ventral epidermal cells; hyaline hair-points 0.2-0.5(-0.8) mm long, terete, weakly denticulate; lamina mostly unistratose, bistratose in 1-2 cell rows at margins in distal part of leaf, sometimes also with narrow bistratose strips; upper and median laminal cells with moderately to strongly thickened walls, gradually elongating to the base, 10-20×9-15 µm to 25-35×10-12 µm, strongly sinuose, basal juxtacostal cells elongate rectangular, 30-70×12-16 µm, with thin to moderately thickened walls, not or slightly porose, basal marginal cells pellucid, with uniformly thin longitudinal and

transverse walls. Autoicous, androecia lateral, hidden just below perichaetia, sporophytes frequent (but only two of four Russian specimens have sporophytes, one from Altai Mts., and one from Caucasus). Setae 2-3 mm, arcuate when moist. Capsules emergent, 1 mm long, ovoid, slightly furrowed. Operculum conic, with short, thick, obtuse beak. Annulus of affinis-type. Peristome teeth entire. Spores 10-13 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: **CAUCASUS:** Karachaevo-Cherkessia, Teberda Reserve, Khadzhibei Gorge, 25.VII.1995, #94/9, Onipchenko (MW); **SIBERIA:** Altai Republic, Karakem River Basin, Ayulyuyuzuk Creek,

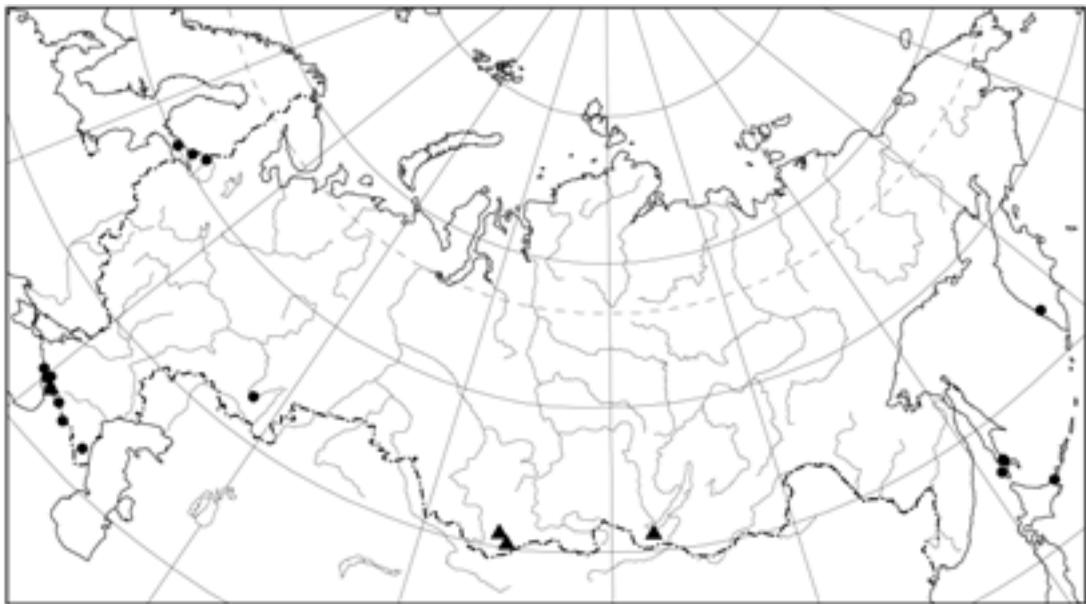


Fig. 18. Distribution of *Grimmia fuscolutea* Hook. (triangles) and *G. hartmannii* Schimp. (circles) in Russia

16.VI.1989, #0 / 476, Ignatov (MHA); Kurkure Range, Kayakatuyarykskij Creek, First Lake, 6.VI.1992, #7 / 152, Ignatov (MHA); **Buryatia**, Baikal area, Khamar-Daban Range, Pereemnaya River, 17.VIII.1989, S.Kazanovskij (MHA).

Distribution. *Grimmia fuscolutea* is known from scattered localities in Europe (Norway, mountains of Central Europe), it occurs in mountains of Africa and South America, Mexico, western North America, in Asia from India, Nepal, China, and Japan, also in Antarctic. In Russia it is known from few localities, in Baikal area, Altai Mts., and Caucasus. In Baikal surroundings it was collected in forest belt, on rocks at river bank, in Altai and Caucasus in alpine belt, at 2500-3350 m elevation, on granitic cliffs and on soil in spotty mountain tundra.

Grimmia fuscolutea was reported for Chukotka (Ignatov & Afonina, 1992; Afonina & Czernyadjeva, 1995) based on wrongly identified specimens, and later excluded from the list of mosses of Chukotka (Afonina, 2004).

Differentiation. *Grimmia fuscolutea* is very rare in Russia, only known from poor or sterile collections. Specimens with sporophytes are easy to recognize by slightly furrowed capsules, arcuate setae in wet condition, short and thick beak of operculum, recurved to revolute leaf margins and uniformly thin-walled basal marginal cells. The similar character combination is known in *G. incurva*, but in latter species leaves are linear and usually considerably longer (2.5-3.5 mm long vs.

1.2-2.0 mm long in *G. fuscolutea*), contorted to almost crisped when dry (vs. slightly flexuose in *G. fuscolutea*), and the upper and median laminal cells are less thick-walled and sinuose. Moreover, *G. incurva* is dioicous, while *G. fuscolutea* – autoicous, with the bud-like perigonia found just below perichaetia. Sterile plants of *G. fuscolutea* are superficially similar to *G. reflexidens*, a species with leaves also narrowly keeled above, but the basal marginal cells of *G. reflexidens* always have transverse walls much thicker than the longitudinal walls. This character differentiates *G. fuscolutea* also from *G. funalis*, similar in mostly unistratose lamina and thick, sinuose cell walls. Moreover, *G. funalis* is dioicous. Differences from *G. elongata* are discussed under the latter species.

11. ***Grimmia hartmannii*** Schimp., Syn. Musc. Eur.: 214. 1860. — *Grimmia brachydictyon* (Card.) Deguchi, J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 16: 173. 1979 '1978'. — *Racomitrium patens* var. *brachydictyon* Card., Bull. Herb. Boissier, ser. 2, 8: 333. 1908. Figs. 18-20.

Plants in loose patches, olive green or yellowish green above, brownish below. Stems prostrate to ascending, moderately branched, to 3-6 cm long, evenly foliated, central strand lacking, tips of shoots usually curved. Leaves flexuose or curved, loosely appressed when dry, patent to spreading when moist, 2.5-3.0×0.5-0.7 mm, from ovate base gradually tapering into long and narrow lanceolate acumen, keeled distally, widely canaliculate proximally; margins plane to weakly

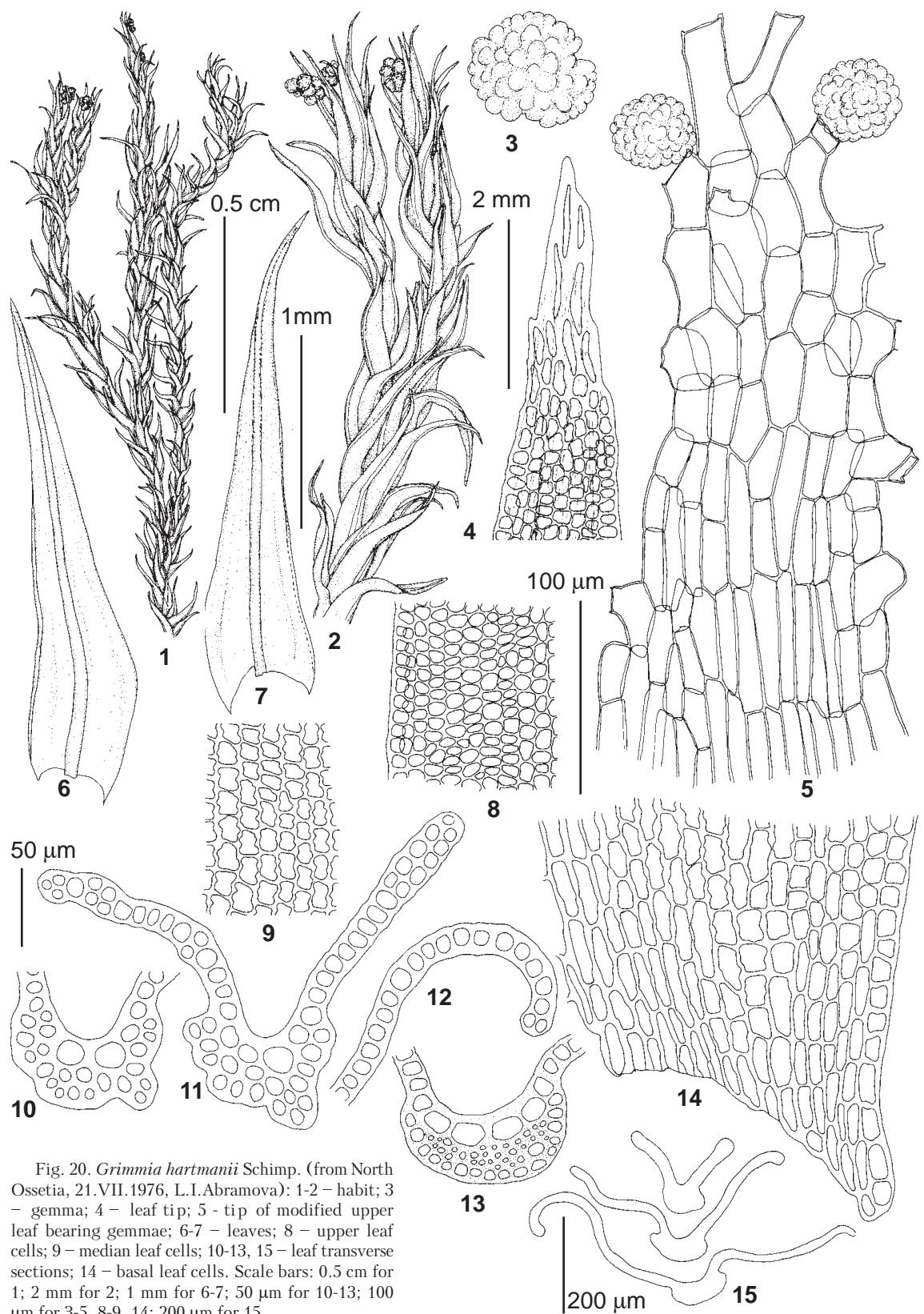


Fig. 20. *Grimmia hartmanii* Schimp. (from North Ossetia, 21.VII.1976, L.I.Abramova): 1-2 – habit; 3 – gemma; 4 – leaf tip; 5 - tip of modified upper leaf bearing gemmae; 6-7 – leaves; 8 – upper leaf cells; 9 – median leaf cells; 10-13, 15 – leaf transverse sections; 14 – basal leaf cells. Scale bars: 0.5 cm for 1; 2 mm for 2; 1 mm for 6-7; 50 µm for 10-13; 100 µm for 3-5, 8-9, 14; 200 µm for 15.

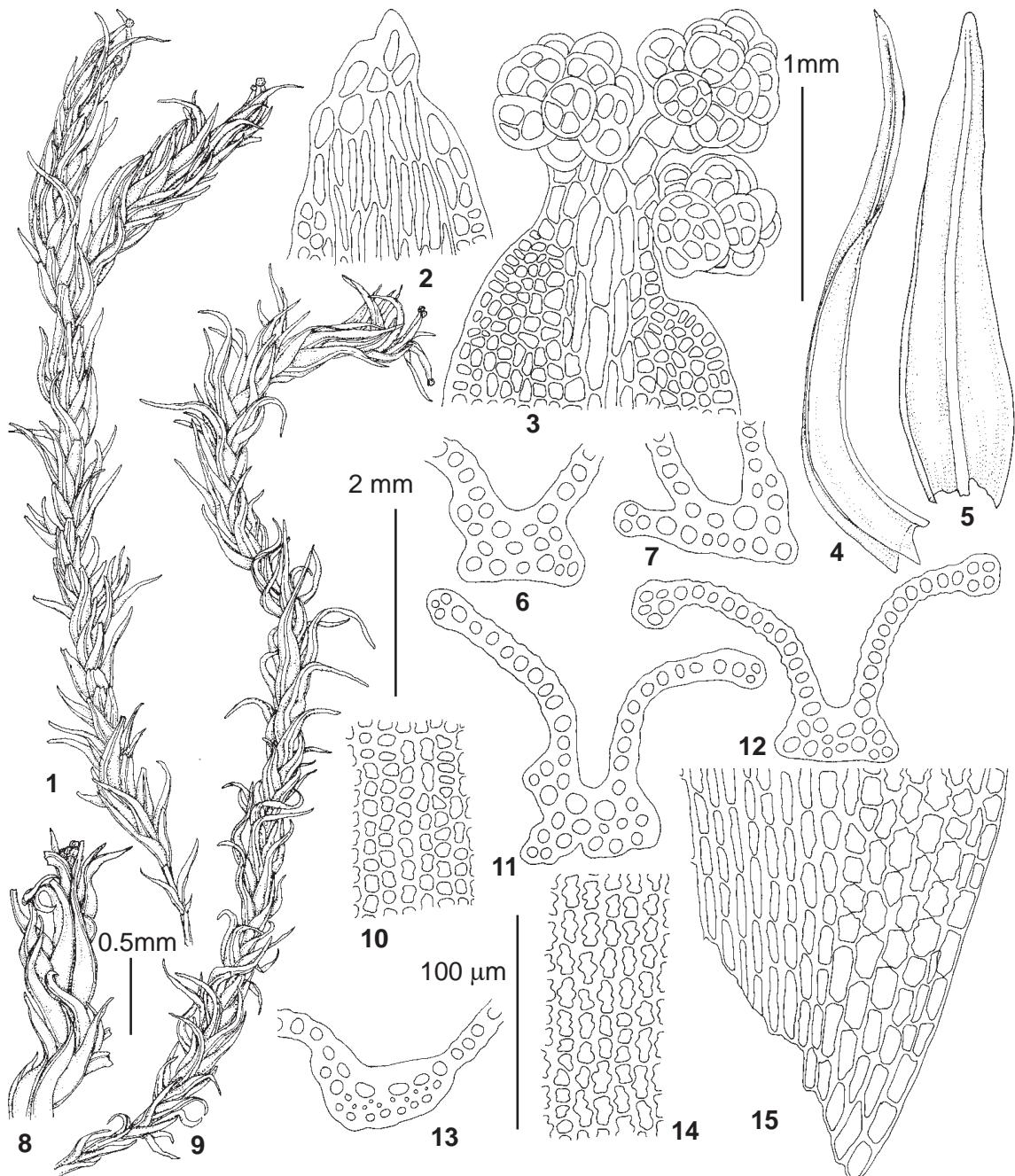


Fig. 20. *Grimmia hartmanii* Schimp. (1-7, 10-11, 13-15 - from Kamchatka, I.Czernyadjeva, #81; 8-9, 12 -from Sakhalin, 6.IX.1966,V.Ardeeva): 1,8-9 - habit; 2 -leaf tip; 3 - leaf tip with gemmae; 4-5 - leaves; 6-7,11-13 -leaf transverse sections; 10 - upper leaf cells; 14 - median leaf cells; 15 - basal leaf cells. Scale bars: 2 mm for 1, 9; 1 mm for 4-5; 0.5 mm for 8; 100 µm for 2-3, 6-7, 10-15.

recurved at distal 1/3 of leaf, more strongly recurved to revolute below on one or both sides; costa differentiated, prominent dorsally, sometimes weakly winged in distal part of leaf, in cross section irregularly angled and asymmetric in distal part of leaf, reniform in proximal part, with differentiated dorsal and ventral

epidermis, ventral epidermal cells (2)-3-7; hyaline hair-points very short, usually 0.1-0.2 mm long; lamina unistratose, at margins bistratose for 1-6 cell rows and sometimes with bistratose strips; upper laminal cells isodiametric, 7-8 µm, rounded-polygonal, with incrassate, not or slightly sinuose walls, median laminal cells

subquadrate to short rectangular, 11-15×7-10 µm, with moderately thickened sinuose walls, basal juxta-costal cells rectangular, 20-40×8-10 µm, thick-walled, porose, basal marginal cells shorter, with thin longitudinal and thick transverse walls. Gemmae frequently developed on tips of normally developed leaves or otherwise on more or less modified, short and hyaline leaves (and in this case appearing in between acumens of normal subterminal leaves), globose, multicellular, 100-200 µm in diameter, yellowish green or yellow when young, dark red or red-brown, more rarely orange when mature. Dioicous, sporophytes rare, not known from the territory of Russia. [Setae 3-4 mm, flexuose when dry, erect or curved when moist. Capsules exserted, ovoid, smooth, 1.5-2 mm long. Operculum conic, with rather long erect or oblique beak. Annulus of affinis-type. Peristome teeth orange or red, irregularly cleft, perforated. Spores 12-16 µm. Calyptrae mitrate].

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:**

Karelia, Kronoborg [Kurkijoki], 16.VIII.1874, E.Juslin (H, LE); Paekjarvi [Pujkkola], 8.VII.1876, V.F.Brotherus (H); Lahdenpohja Distr., Kurkijoki, 31.VII.1999, #20-897, Maksimov & Maksimova (PTZ); **Leningrad Province**, Tuvisaari [Sovetskij], 11.IX.1895, ? (H); Viipuri [Vyborg], V.1875, E.Lang (H); Hogland, 8.VIII.1868, M.Brenner (H); **CAUCASUS:** **Dagestan**, Karak, 29.VI.1925, I.Bogdanovskaya-Gienef (LE, MW); **Kabardino-Balkaria**, Elbrus Mt. S-facing slope, 1959, Vladimirova (LE, MW); **North Ossetia**, North Ossetian Reserve, 21-27.VII.1976, #2, 122, 153, 23.VII.1980, #79, 80, 83 L.I.Abramova (MW); **Karachaevo-Cherkessia**, Teberda Reserve, Alibek Gorge, 23.VIII.1955, A.L.Abramova & I.I.Abramov (LE); Malaya Khati para Gorge, 21.VIII.1955, #143, A.L.Abramova & I.I.Abramov (H, LE); Mukhu Gorge, 31.VII.1994, #142/94, Onipchenko (MW); **Krasnodar Territory**, Adler Distr., Krasnaya Polyana, 5.IX.1937, A.Lazarenko (LE), 22.VII.1948, I.M.Raspopov (LE); Aibga Mt., 1.VI.1951, V.Alper (CSR, MHA); Urushten River basin, Sinyaya Creek, 7.VIII.2000, T.Akatova (CSR); Alous Mt., 14.VIII.1994, T.Akatova (CSR, MHA); Malaya Laba River basin, Akhtsarkhva Mt., 16.VII.2001, T.Akatova (CSR); Mzymta River basin, Kogot Mt., 4.VIII.2000, T.Akatova (CSR, MHA); Achishkho Ridge, 16.VIII.1996, 14.VIII.2004, T.Akatova (CSR, MHA); Sochi Distr., Lazarevskoe, 30.VII.1927, Ya.Vasiljev (H); **Adygeya**, Belaya River, 6.VIII.1999, T.Akatova (CSR, MHA); Guzeripl, 13.VI.1995, T.Akatova (CSR, MHA); Suvorovskij kordon, 15.VI.1995, T.Akatova (CSR, MHA); Belaya River at Imeretinka Creek mouth, 9.VIII.1999, T.Akatova (CSR, MHA); **URALS:** **Bashkortostan**, Shulgan-Tash, #42a, O.Zhigunov (UFA); **FAR EAST:** **Kamchatka Province**, Kihchik River, 10.VIII.2001, #81, I.Czernyadjeva (LE); **Sakhalin Province**, Sakhalin Island, Nevelsk surroundings, 27.IX.1964, V.Ya.Cherdantseva (VLA); Aniva Distr., Susunajskij Range, Majorskaya Mt., 6.IX.1966, V.Ya.Cherdantseva (VLA, IRK); Dolinskij Distr., 7.IX.1964, V.Ya.Ardeeva (IRK); Kuril Islands, Kunashir, Goryachij Plyazh, Vtoraya Rechka, 30.VII.1978, V.Ya.Cherdantseva (VLA).

Distribution. *Grimmia hartmanii* is common in mountain areas of Europe, from southern Scandi-

navia and Great Britain to Spain, also in Transcaucasia and Turkey, Japan, eastern North America. In Russia it is rather common in Caucasus, but very rare in north-western European Russia, South Urals, and Far East (Sakhalin and Kamchatka), from where it is known from few localities. It grows on acidic and neutral rocks, usually in the forest belt.

Differentiation. *Grimmia hartmanii* is usually easy to recognize by its red-brown, comparatively large globose gemmae formed in clusters at shoot tips. Another diagnostic character is the large size of the plants (3-6 cm long), the ascending and evenly foliated stems with curved shoot tips, the strong costa, reniform in cross section, widely canaliculate in middle part where it has 3-7 ventral epidermal cells. *Grimmia hartmanii* usually resembles *G. ramondii*, and their differences are discussed under the latter. Reniform costae are also characteristic of *G. longirostris*, but this species differs from *G. hartmanii* in smaller plant size (stems to 2-3 cm long), erect stems, and gemmae absence. *Grimmia anomala* has similar gemmae in size and position, and it is sometimes treated as a variety of *G. hartmanii*. *Grimmia anomala* differs mainly in having striolate lamina due to the well-developed longitudinal cuticular ridges, which look similar to papillae in leaf cross section (vs. laminal cells without cuticular ridges, smooth or with small thickenings above cell joint in transverse leaf section in *G. hartmanii*). Also *G. anomala* has smaller gemmae (70-80 µm vs. 100-200 µm in *G. hartmanii*), that are yellowish (vs. red-brown in *G. hartmanii*) and occur always on normally developed upper leaves, whereas in *G. hartmanii* gemmae often (though not always) found on modified, short and hyaline leaves and thus look subaxillary.

Several specimens from Sakhalin reported as *G. anomala* (Savicz-Lyubitskaya & Smirnova, 1970) belong to *G. hartmanii* because they lack longitudinal cuticular ridges.

Far East collections differ from Caucasus plants in smaller plant and leaf size (leaves 2.0-2.3 mm long vs. 2.5-3.0 mm in Caucasus specimens), more strongly flexuose dry leaves (contrary to mostly straight leaves of *G. anomala*), and smaller gemmae (ca. 100 µm vs. 100-200 µm in Caucasus plants), orange (vs. red-brown in Caucasus plants), forming both on tips of normal and small modified leaves (vs.

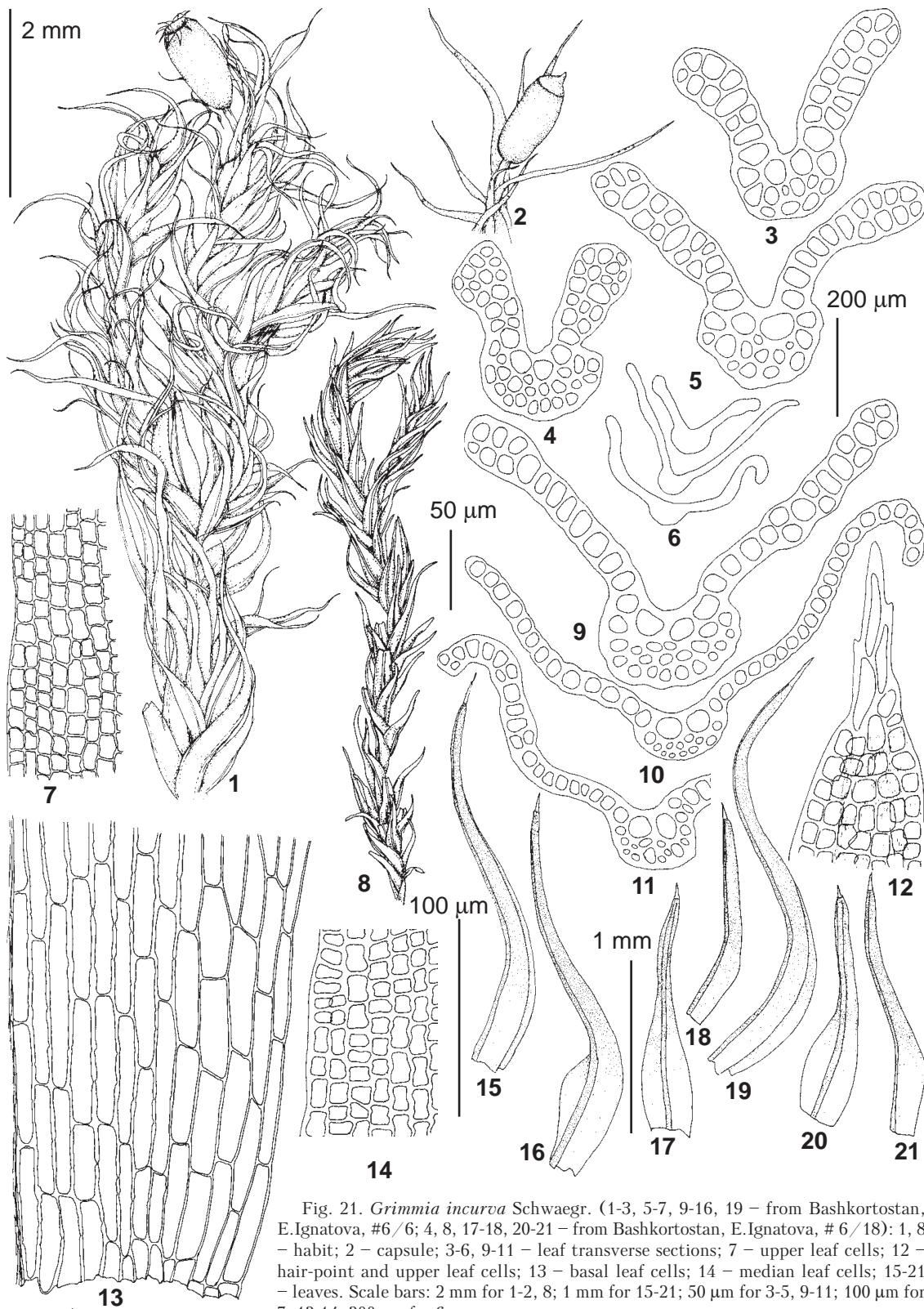


Fig. 21. *Grimmia incurva* Schwaegr. (1-3, 5-7, 9-16, 19 – from Bashkortostan, E.Ignatova, #6/6; 4, 8, 17-18, 20-21 – from Bashkortostan, E.Ignatova, #6/18): 1, 8 – habit; 2 – capsule; 3-6, 9-11 – leaf transverse sections; 7 – upper leaf cells; 12 – hair-point and upper leaf cells; 13 – basal leaf cells; 14 – median leaf cells; 15-21 – leaves. Scale bars: 2 mm for 1-2, 8; 1 mm for 15-21; 50 µm for 3-5, 9-11; 100 µm for 7, 12-14; 200 µm for 6.

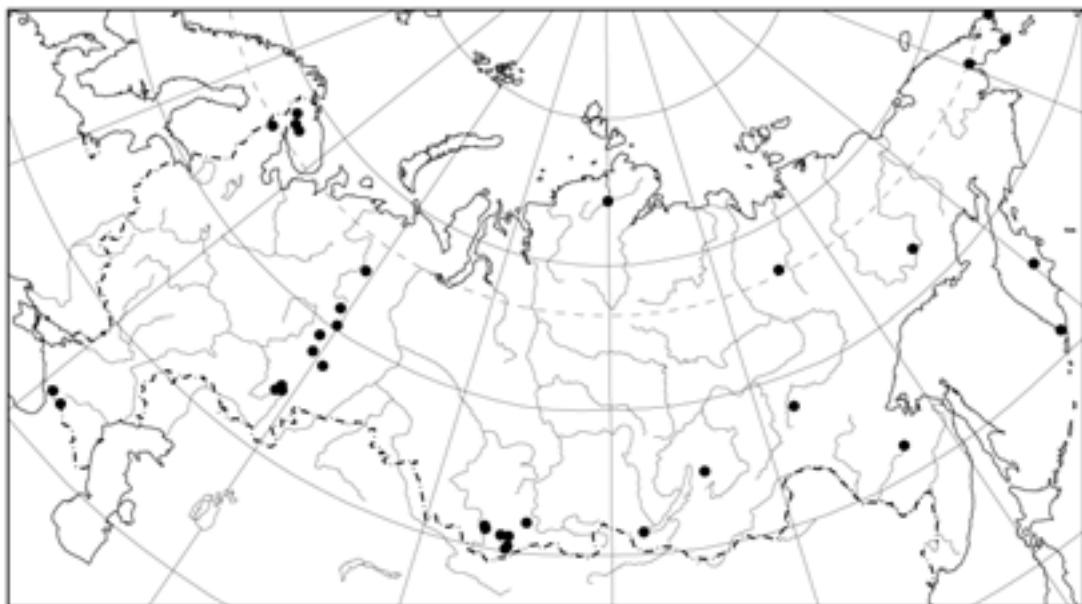


Fig. 22. Distribution of *Grimmia incurva* Schwaegr. in Russia.

usually on modified upper leaves in Caucasus plants). These Far East populations are very similar to Japanese collections of *G. brachydictyon*. The latter species was synonymized by Muñoz & Pando (2000) with *G. hartmanii*. Deguchi (1978) and Greven (2003), however, recognize *G. brachydictyon* as a separate species and point out the following differences from *G. hartmanii*: 1) smaller plant size, smaller leaves and gemmae; 2) costa winged on dorsal side in distal part of leaf; 3) hair-point very short or leaves muticous. However, in *G. hartmanii* costa also has low wings on dorsal side, and hair-points are rather short.

12. *Grimmia incurva* Schwaegr., Sp. Musc. Suppl. 1(1): 90. 1811. Figs. 21, 22.

Plants in loose or dense rounded cushions, dark green or blackish-green. Stem erect, (1)-2-3 cm long. Leaves contorted to crisped when dry (in small forms flexuose, loosely appressed), (1)-2.5-3(-4)×(0.3-)0.4-0.6 mm, linear-lanceolate, sharply keeled distally; margins plane in distal part of leaf, recurved on one side below; costa differentiated, strongly prominent dorsally, semi-circular in cross section, with 2 ventral epidermal cells; hyaline hair-points short to absent; lamina mostly bistratose in distal 1/3, to 4-stratose at margins, in middle part of leaf bistratose in 4-6 cell rows at margins, unistratose near costa, in basal part of leaf unistratose; upper laminal cells subquadrate, 9-14 µm, with moderately thickened and slightly sinuose walls, median laminal cells with moderately to strongly sinuose walls, basal juxta-

costal cells elongate rectangular, with thick and porose longitudinal walls and thin transverse walls, basal marginal cells slightly shorter, pellucid, with uniformly thin longitudinal and transverse walls. Dioicous, sporophytes rare. Setae 2-3 mm, arcuate when moist. Capsules emergent, ovoid-cylindric, smooth. Operculum conic, with short beak. Annulus of affinis-type. Peristome teeth orange, strongly perforated. Spores 10-12 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: EUROPEAN RUSSIA:

Murmansk Province, Kandalaksha Distr., Kuoloyarvi, Salatunturi Mt., 23.VII.1957, #378, R.Shlyakov (KPABG); Salla, Tuutsan, 21.VII.1938, O.Lumiala (H); Khibiny Mts., Rasvumchorr Plateau, 28.VIII.1948, #2240, 1172, R.Shlyakov (KPABG); Khibiny Mts., Kukisvumchorr Mt., 4.IX.2001, Ignatova (MW); Takhtavumchorr Mt., Molibedenovyj Cirque, 2.IX.1994, #31a-94, A.Likhachev (KPABG); Khibiny Station, Medvezhij Log, 12.VIII.1949, #2386, R.Shlyakov (KPABG); Chil'tald Mts., Chil' Creek, 28.VI.1988, #29-2-88, 29-5-88, 135-1-88, 135-12-88, O.Belkina (KPABG); Chil'tald Mts., Malaya Konjya Mt., 26.VI.1988, #5-3-88, 5-6-88, 11-1-88, O.Belkina (KPABG); Lavna-tundra Mts., Peak 638 m, 24.VII.1987, #95-1-87, O.Belkina (KPABG); Lavnatundra Mt., 30.VII.1987, #145/2, 143/6, O.Belkina & A.Likhachev, 7.VIII.1987, #295-5-87, 109-87, 105-1-87, 105-3-87, O.Belkina (KPABG); **Karelia**, Loukhi Distr., Paanayarvii National Park, Kivakka Mt., 8.IV.2000, #24-226, A.Maksimov & T.Maksimova (MW); **CAUCASUS: Karachaevo-Cherkessia**, Teberda Reserve, Mussa-Achitara Mt., 6.VIII.1986, Ignatova (MHA); Oriuchat Gorge, 3.IX.1994, #161/94, Onipchenko (MW); Goraly-Kol Gorge, 13.VIII.1986, Ignatova (MHA); Malaya Khati para Gorge, 30.VIII.1983, 6.VII.1994, #9/94 & 16.V.2001, Onipchenko (MW), 4.VIII.1986, Ignatova (MHA); Kyshkadzher Gorge, 10.VII.1994, #37/94, Onipchenko (MW); **Adygeya**, Caucasian Reserve, Achishkho Mt., 16.VIII.1996, T.Akatova (CSR); **URALS: Komi Republic**, Sablya Mt., 9.VIII.1984,

A.P.Djachenko (SVER); **Perm Province**, Basegi Reserve, Southern Baseg, 9.VI.1994, #37, *Ignatov & Bezgodov* (MW); Srednj Baseg Mt., 7.VI.1992, #20, 191, *A.Bezgodov* (MW); 16.VI.1993, #191, *A.Bezgodov* (MW); Vishera Reserve, Tulymskij Kamen Range, 1.VII.1994, #317, *A.Bezgodov* (MW); Tulymskij Kamen Range, 12.VII.1994, #443, *A.Bezgodov* (MW); 21.VII.1994, #513, *A.Bezgodov* (MW); **Sverdlovsk Province**, Rezh Distr., Rezh river valley, Pershino environs, 23.VII.1996, *I.Goldberg* (SVER); Alapaevsk Distr., Rezh river valley, Katushka Creek, 23.VI.2000, *I.Goldberg* (SVER); Denezhkin Kamen Mt., 28.VII.1996, A.P.Djachenko (SVER); **Bashkortostan**, Beloretsk Distr., Yamantau Mt., 12.VII.1997, #48, *A.I.Solomeshch* (MW); Bolshoj Iremel Peak, 6.IX.1990, #6/18, 6/6, 6/9, 6/18, 6/15, 3/10, *Ignatova* (MW); South Ural' Reserve, B.Shelom Mt., 4.VII.1998, #33, *A.A.Muldashev* (MW); **SIBERIA: Altai Republic**, Kurajskij Range, N of Kosh-Agach, Tabozhok Peak, 1.VIII.1992, #31/8, 31/12, 31/13, 31/14, *Ignatov* (MHA); pass between Bashkaus & Pravyj Bogoyash Rivers, 26.VII.1993, #36/346, *Ignatov* (MHA); Bogoyash Creek upper course, 27.VII.1993, #36/99, *Ignatov* (MHA); pass between Kolbakaya and Saluru Creeks, 31.VII.1993, #36/71, *Ignatov* (MHA); Karakem River Basin, Ayulyuyuzuk Creek upper course, 16.VI.1989, #0/927, *Ignatov* (MHA); Karakem River Basin, Kobigayul Creek, 15-19.VI.1989, #0/471, 0/907, 0/906, 0/883, 0/361, 0/421, 0/187, 0/902, 0/930, *Ignatov* (MHA); between Ayulyuyuzuk & Kobigayul, 15.VI.1989, #0/901, 0/934, *Ignatov* (MHA); Shapshal Range, 22.VII.1935, #1108, *M.Khomutova* (MW); Shapshal Range, SE of Uzunkul' Lake, 23.VI.1990, *N.Zolotukhin* (MHA); Shapshal Range, Trekhglavaya Peak top, 19.VII.1990, *N.Zolotukhin* (MHA); Shapshal Range, Uzunoyuk Creek upper course, 9.VII.1990, *N.Zolotukhin* (MHA); Shapshal Range, Booshkon pass, 5.VII.1990, *N.Zolotukhin* (MHA); Kurkure Range, Kayakkatuyarykskij Creek Basin, left branch, 28.VI.1991, #8/23, *Ignatov* (MHA); Kurkure Range, Kayakkatuyarykskij Creek upper course, 30.VI.1991, #7/4, 7/168, 7/38, *Ignatov* (MHA); Kurkure Range, Kayakkatuyarykskij Creek Basin, First Lake, 3.VII.1991, #7/152, 8/336, 3/139, *Ignatov* (MHA); Second Lake, 3.VII.1991, #3/182, 3/260, 3/72, 3/264, 3/270, 7/78, *Ignatov* (MHA); Kurkure Range, between Kayak & Kayakkatuyarykskij Creeks, 4.VII.1991, #7/50, 7/56, 7/57, *Ignatov* (MHA); Kayakkatuyarykskij Creek Basin, upper course, 30.VI.1991, #7/171, *Ignatov* (MHA); Tamanel Peak, 8.VII.1993, #34/87, 34/88, 28/111, *Ignatov & Ignatova* (MHA); Shebalino Distr., Karakol Lakes, 3.VIII.1991, *Ignatov & Ignatova* (MHA); **Krasnoyarsk Territory**, Taimyr, Taimyr Lake, Ledyanova Bay, 28.VII.2004, #G19, *V.Fedorov* (MW); Western Sayan Mts., Ora-sug Creek upper course (Kantegir River tributary), 19.VII.1965, *S.Gudoshnikov & V.Timonin* (MHA, IRK); Western Sayan Mts., Sinyaya Creek (Golaya tributary), 21.VIII.1991, #2098-11, *V.B.Kuvaev* (MW); **Buryatia**, Khamar-Daban Mts., Slyudyanka River, 20.VII.1990, *S.Kazanovskij* (IRK, MW, MHA); Dzherginskij Reserve, 12.VII.2002, #12, *D.Tubanova* (UUH); **Yakutia**, Kobyajskij Distr., Kele River upper course, Kyunkyunur Creek, 26.VII.1987, *E.G.Nikolin* (SASY); 30.VI.1987, *E.G.Nikolin* (SASY); Neryungri Distr., Khatyngga River basin, Urga Creek, 18.VIII.1995, *E.I.Ivanova* (SASY, MW); **FAR EAST: Khabarovsk Territory**, Verkhnebureinskij Distr., Bureinskij Reserve, Lan-Balaganakh watershed, 22.VIII.1989, #89-M-230, *O.Grigorjeva* (MHA); **Chukotka**, Provideniya Bay, 23.VIII.2001, *O.M.Afonina* (LE); Bering Strait, *C.Wright*, #78 (FH); Crux Bay, Aegvekinot Settlement, 20.VI.1969, #1, *O.M.Afonina* (LE); **Magadan Province**, Tenkinskij Distr., Sibit-Tyellakh village, 14.VII.1976, *L.S.Blagodatskikh* (LE); **Kamchatka**, Koshelevskij volcano, VII.1990, *I.V.Czernyadjeva* (LE); Ushkovskij volcano slope, 14-19.VII.2003, *I.V.Czernyadjeva* (LE).

Distribution. *Grimmia incurva* is distributed in the Holarctic from the Arctic to southern Europe, Tibet, central China, Japan, but rare in North America (Crum & Anderson, 1981). In Russia it is not rare in Caucasus, Kola Peninsula, Middle and South Urals, Altai Mts., scattered in Western and Eastern Sayan Mts., Taimyr, Yakutia, Khabarovsk Territory, Magadan Province, Chukotka, and Kamchatka. It grows at a wide range of elevations (400-3400 m alt.), mostly in alpine belt, rarely below tree-line, on rocks, in rock crevices and nishes, usually in shaded habitats, more rarely on exposed places.

Differentiation. *Grimmia incurva* is usually readily recognized by very long, liner-lanceolate, contorted to almost crisped leaves. Another helpful character – basal juxtacostal cells with thick and porose, nodulose longitudinal walls contrasting with very thin transverse walls (see illustrations in Ignatov & Cao, 1994), and also uniformly thin-walled basal marginal cells. In alpine belt, in severe conditions small forms with almost straight leaves and practically without hyaline hair-points are found; in such plants costa is very wide, filling most of subulate distal part of leaf, leaf tips are often fragile, and basal juxtacostal cells not nodulose. The differentiation from other species with uniformly thin-walled basal marginal cells, *G. fuscolutea* and *G. elongata*, is discussed under these species; *G. donniana* also has thin-walled basal marginal cells, but it differs in greish color of plants and usually numerous exserted capsules.

13. *Grimmia jacutica* Ignatova, Bedn.-Ochyra, Afonina et Muñoz, Arctoa 12: 5. 1D; 2-1, 2, 4, 6, 8, 10, 12-14; 3-3-11; 4-1-10. 2004. Figs. 23-25.

Plants in loose, easily separating tufts or patches, olive green or yellowish green above, brownish below. Stems ascending, (3)-4-5(-8) cm long, weakly branching, reddish, without central strand. Leaves often slightly secund, flexuose, loosely appressed when dry, usually with recurved leaf tips, erect-spreading when moist, 2.1-3.0×0.5-0.8 mm, from ovate base gradually tapering into long and narrow lanceolate acumen; margins recurved on one side in proximal 1/2-2/3 of leaf and plane or weakly and shortly recurved on other side; costa differentiated,

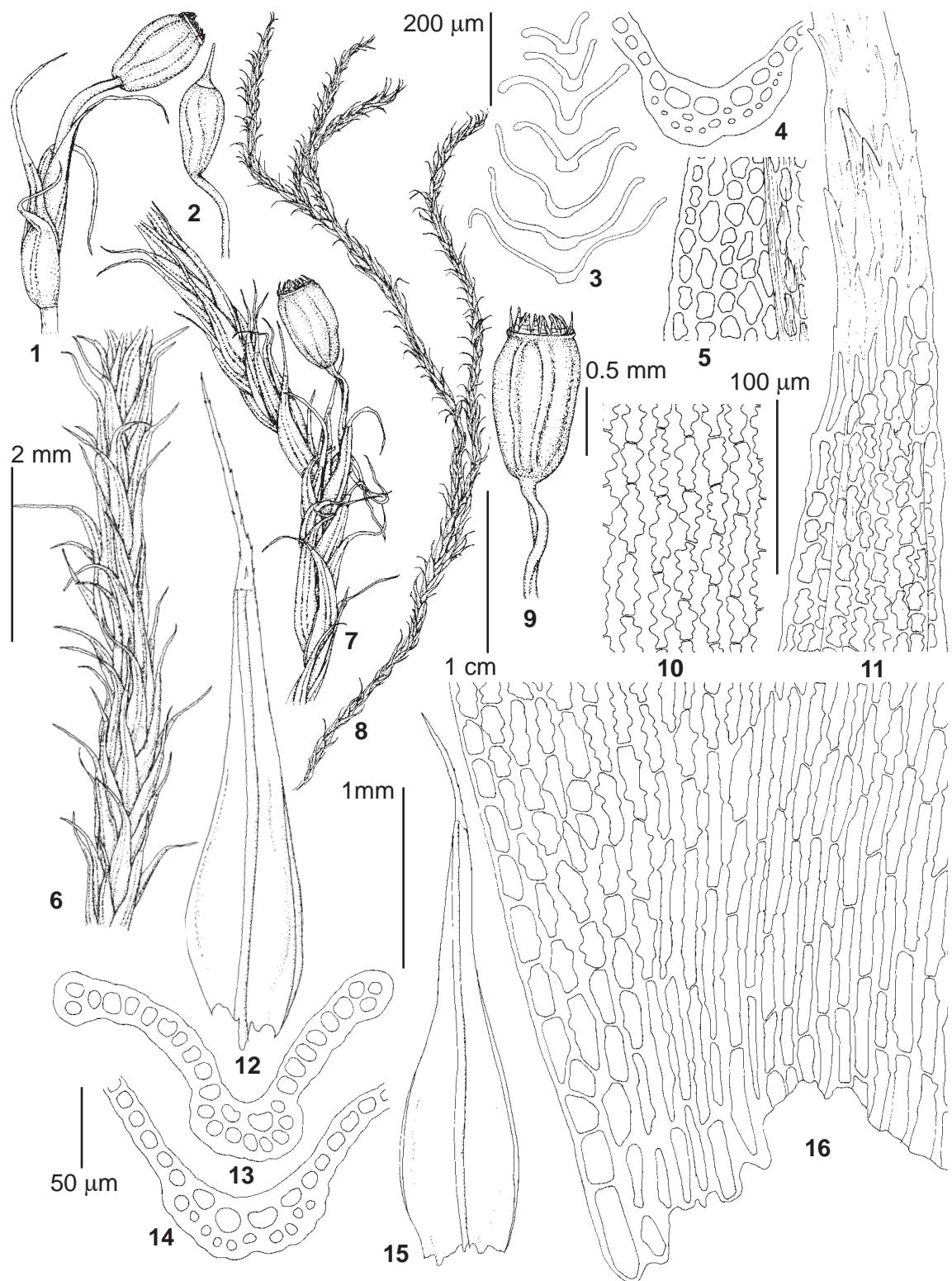


Fig.23. *Grimmia jacutica* Ignatova, Bedn.-Ochyra, Afonina & Muñoz (from holotype, Yakutia, 6.IX.1990, E.Akimova): 1-2, 7, 9 – capsules; 3-4, 13-14 – leaf transverse sections; 5 – upper leaf cells; 6, 8 – habit; 10 – median leaf cells; 11 – base of hair-point and upper leaf cells; 12, 15 – leaves; 16 – basal leaf cells. Scale bars: 1 cm for 8; 2 mm for 1-2, 6-7; 1 mm for 12, 15; 0.5 mm for 9; 50 µm for 4, 13-14; 100 µm for 5, 10-11, 16; 200 µm for 3.

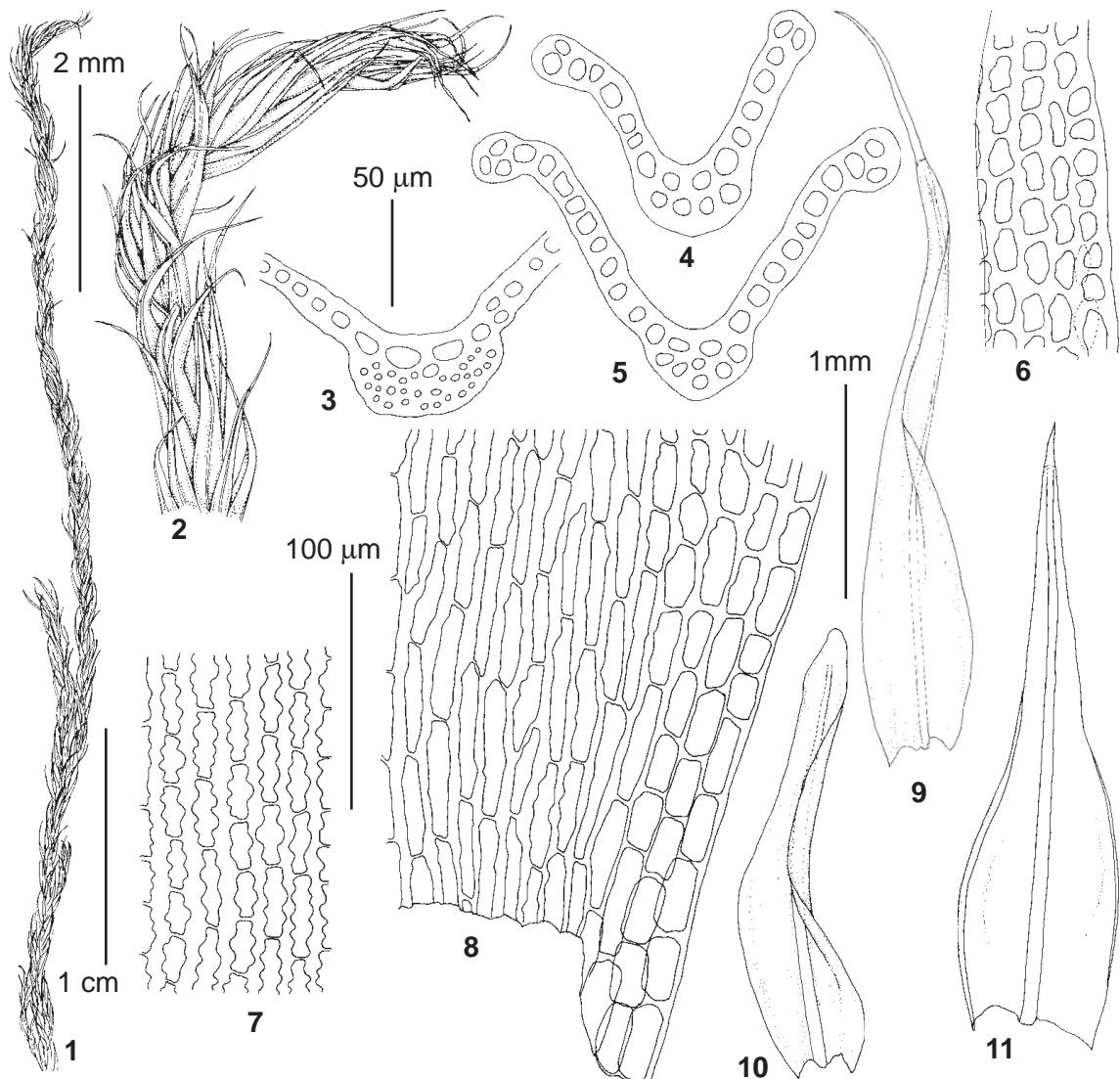


Fig.24. *Grimmia jacutica* Ignatova, Bedn.-Ochyra, Afonina & Muñoz (1-9 – from Chukotka, Yanrakynnot, 23.VII.1976, O.Afonina; 10 – from Yakutia, Tiksi, 21.VII.1979, V.R.Filin; 11 – from Amurskaya Province, 23.VII.1915, Prokhorov & Kuzeneva): 1-2 – habit; 3-5 – leaf transverse sections; 6 – upper leaf cells; 7 – median leaf cells; 8 – basal leaf cells; 9-11 – leaves. Scale bars: 1 cm for 1; 2 mm for 2; 1 mm for 9-11; 50 µm for 3-5; 100 µm for 6-8.

prominent dorsally, canaliculate ventrally, reniform in cross section, with 3-4(5) ventral epidermal cells, mostly bistratose, rarely 3(-4)-stratose; hyaline hair-points 0.1-1.2 mm long, mostly 0.5-0.7 mm long, terete distally, slightly widened and flattened at base, straight or weakly flexuose, often recurved when dry, slightly or moderately denticulate; lamina unistratose, bistratose in one cell row at margins; upper laminal cells short rectangular mixed with subquadrate, thick-walled, sinuose, 7-18×9-11 µm; median laminal cells elongate rectangular, 12-25(30)×(9)10-12 µm, with very strongly thickened and sinuose, pale longitudinal walls and very thin transverse walls; basal juxtacostal cells linear, 25-50(-90)×9-11 µm, strongly incrassate and porose,

basal marginal cells with thick and straight longitudinal and transverse walls. Dioicous. Male plants with smaller leaves, 2.0-2.3×0.5-0.7 mm, and shorter hyaline hair-points, 0.1-0.3(-0.5) mm long; perigonia numerous, terminal but becoming lateral after innovation growth. Sporophytes very rare (but perichaetia with not fertilized archegonia are frequent, terminal but becoming lateral after innovation growth). Perichaetal leaves similar to stem leaves, 2.2-2.7×0.5-0.7 mm, with longer hyaline hair-points, to 1.6 mm. Setae 1.8-2.0 mm long, arcuate when moist. Capsules exserted, ovoid, ca. 1.0×0.7 mm, ribbed; stomata at urn base. Annulus of affinis-type. Peristome teeth orange, finely papillose, entire, weakly perforated. Operculum

low conic, with long erect beak. Calyptrae not seen. Spores 13-18 µm.

SPECIMENS EXAMINED: **SIBERIA: Krasnoyarsk Territory**, Taimyr, Taimyr Lake, Ledyanaya Bay, 22.VII.2004, #G5, G17, *V.Fedosov* (MW); Putorana Plateau, Kapchuk Lake, 3.VIII.1978, *Vilde* (LE); Putorana Plateau, Ayan Lake, 19.VII.1983, *I.Czernyadjeva* (LE); Evenkiya, Nizhnyaya Tunguska River, 20.VII.1932, *A.Rubin & I.Maskil'* (LE); Podkamennaya Tunguska River, 8.VIII.1994, #281, 282, *S.Shcherbina* (MW); **Yakutia**, fl. Aldan, 1911, *Tl.W.Sokolow* (H-Br); Aldanskij Distr., Nizhnij Nimnry Village, 21.VII.1995, *E.Ivanova* (MHA); Aldanskij Distr., Uchur River, Chagda Village, 28.VII.1991, *E.Ivanova* (SASY, MW); Aldanskij Distr., Uchur River, Kurung-Khokhoe Aryt Island, 1.VIII.1991, *E.Ivanova* (SASY, MW); Aldanskij Distr., Uchur River near Sivalga River mouth, 23.VII.1991, *A.Protopopov* (SASY, MW); Aldanskij Distr., Ili River, 8.VII.1991, *E.Ivanova* (SASY, MW); Aldanskij Distr., Emeldjak Village, 6.IX.1991, *E.Tyrlygina* (SASY, MW); Aldanskij Distr., Gynym River, 11.VII.1991, *A.Protopopov* (SASY, MW); Bulun Distr., Sokurdakh Mt., 2.VII.1960, *V.R.Filin* (MW); Bulun Distr., Tiksi, 21.VII.1979, *V.R.Filin* (MW); Kobyajskij Distr., Undyulyung River, 13.VI.1990, *A.Kazantsev* (SASY, MW); Kobyajskij Distr., Undyulyung River upper course, 12.VI.1990 & 14.VI.1990, *E.Nikolin* (SASY, MW); Kobyajskij Distr., Kele River at Kyunkunyur Creek mouth, 29.VII.1987, *E.Nikolin* (SASY, MW); Kobyajskij Distr., Kyunkunyur Peak, 30.VI.1987, *E.Nikolin* (SASY, MW); Kobyajskij Distr., Kele River at Kumkandra Creek mouth, 4.VIII.1987, *E.Nikolin* (SASY, MW); Kobyajskij Distr., Lyampushka River, 15.VII.2002, *E.I.Ivanova* (SASY, MW); Mirinskij Distr., Vilyuj River, 22.VII.1990, #1/6, *A.Isaev* (SASY, MW); Neryungri Distr., Tokinskij Stanovik, Utuk River, 24.VIII.1987, *K.Volotovskij* (SASY, MW); Neryungri Distr., Toko Lake, 10.VIII.1987, *K.Volotovskij* (SASY, MW); Suntarskij Distr., Chona River, Dyrat, 16.VII.1958, #8/2, 29/11 & 20/1, *V.Usanova* (SASY, MW); Suntarskij Distr., Vilyuj River at Lakhargaana Creek mouth, 12.VIII.1958, #101/7, *P.Kil'dyushevskij* (SASY, MW, LE, KRAM); Olyekminskij Distr., Choruoda River, 28.VII.1995, *K.K.Krivoshapkin* (MW); Tompo Distr., Tukulan River at Temirdaaekh Creek mouth, 4-6.IX.1990, *E.Akimova* (SASY, MW); Tompo Distr., Tukulan River upper course, peak 1301 m, 3.IX.1990, *E.Akimova* (SASY, MW); Tompo Distr., Eastern Verkhoyan Mts., Eketchan River upper course, 23.VI.1956, #74/7, *L.Dobretzova* (SASY, MW); Tompo Distr., Eastern Verkhoyan Mts., Aemykchan River upper course, 13.VIII.1955, 1#89/3, *L.Dobretzova* (SASY, MW); Tompo Distr., Eastern Verkhoyan Mts., Barykchan River middle course, 29.V.1955, #24/11, *V.Ivanova* (SASY, MW); Tompo Distr., Verkhoyan Mts., Nulkasig River upper course, 27.VII.1956, #105/3, *V.Ivanova* (SASY, MW); Tompo Distr., Sette-Daban Range, 21.VI.1999, *E.I.Ivanova & K.K.Krivoshapkin* (SASY, MW); Tompo Distr., Suntar-Khayata Range, Kyurbulyakh Creek, 17.VII.2003, *E.I.Ivanova & V.I.Zolotov* (SASY, MW); Tompo Distr., Suntar-Khayata Range, Nekyulyakh Creek, 14.VII.2003, *E.I.Ivanova & V.I.Zolotov* (SASY, MW); Ust-Mayá Distr., Allakh-Yun, Tarbagannakh Creek, 25.VIII.2000, #00-350, *M.Ignatov* (MHA); Ust-Mayá Distr., Allakh-Yun, Semenchi-Yuryakh Creek, 26.VIII.2000, #00-356, *M.Ignatov* (MHA); Ust-Mayá Distr., Solnechnyj Village, 3.IX.2000, #00-355, *M.Ignatov* (MHA); Kobyajskij Distr., Undyulyung River at Byrandja Creek mouth, 11.VII.1990, *E.Nikolin* (SASY, MW), 12.VII.1990, *E.Ivanova* (SASY, MW); Kobyajskij Distr., Sobolokh-Mayan River at Kuolanda Creek mouth, 26.VIII.1991, *B.Borisov & S.Kirillina* (SASY, MW); Kobyajskij Distr., Sobopol River, 2.VIII.1958, #70/8, *L.Dobretzova* (SASY, MW); **Buryatiya**, Khamney River upper course, 1912, #3730, *V.Smirnov* (LE); Baikal Lake, Bolshaya Cheremshanaya Creek, 23.VII.1956, *L.V.Bardunov* (IRK, MW); Eastern Sayan Mts., Mondy Village surroundings, 22.VIII.1960, *L.V.Bardunov* (IRK, MW); ad fontes fl. Chamkol, 1912, *V.Smirnov* (H-Br); distr. Troizkosavsk, prope fl. Chamneja, 1912, *V.Smirnov* (H-Br); Dzherginskij Reserve, 16.VII.2002, #19, *D.Tubanova* (UUH); **Chita Province**, Shilka River, Boty Creek upper course, 30.VIII.1963, *L.V.Bardunov* (IRK, MW); Namina River, 1000 m, 31.VII.1989, *V.R.Filin* (MW); **FAR EAST: Amurskaya Province**, Zeya Nature State Reserve, 28.VIII.1979, #75, 2.V.1979, #358, 5.IX.1979, #128, *D.Petelin* (MW); 23.VIII.1980, #331, *L.I.Abramova* (MW), 22.VIII.1980, *N.Stezura* (LE); Bokongro Creek, 31.VII.1911, #186, *N.Prokhorov & O.Kuzeneva* (LE); fl. Zeja, Tukuringra, 21.VII.1910, 23.VII.1915, 1.IX.1915, *O.Kuzeneva* (H-Br); Selemdzha Distr., Bryus Mt., 8.VIII.1976, *V.Ya.Cherdantseva* (VLA, MW); **Khabarovsk Territory**, Verkhnebureinskij Distr., Peak 1923 m, 3.VIII.1989, #89-M-52, 89-M-49, *B.Khasanov* (MHA); Lednikovyj Creek, 21.VIII.1987, *M.Galkina* (MHA); watershed of Lan & Balagankh Rivers, 24.VIII.1989, #89-M-224, *O.Grigorjeva* (MHA); Medvezh'e Lake, 10.VIII.1997, #97-195, 97-368, *B.Tan* (MHA); Medvezh'e Lake, 8-10.VIII.1997, #97-1107, 97-2002, 97-2006, 97-2013, *M.Ignatov* (MHA); Sovetskij Distr., Tumnin River, Aiga Mt., 15.IX.1945, *B.Kolesnikov* (LE); **Evreiskaya Autonomous Province**, Bastak Reserve, Bydry Peak, 13.VIII.2000, *Rubzova* (VLA); **Primorskij Territory**, Oblachnaya Peak 1400-1855 m, 31.VII.1980, 9.V.Ya.Cherdantseva (VLA); Sikhote-Alin Reserve, Zakharovsky Creek, 11.VIII.1979, *I.A.Flyagina* (VLA); South Sikhote-Alin, Tskhamodynza Mt., 5.IX.1959, *V.M.Ponomarenko* (LE, MW); **Chukotka**, Yablon River, 9.VIII.1982, *O.M.Afonina* (LE, KRAM); Tanuyrer River, Bezymjannoe Lake, 1.VIII.1978, 6-14.VII.1979, *O.M.Afonina* (KRAM, LE); Ilmyneiveem River, 1.VIII.1978, *O.M.Afonina* (KRAM, LE); Televeem-Pervaya River, 23.VII.1979, *O.M.Afonina* (KRAM, LE); Tanuyrer River, mouth of Kujviveemkej Creek, 10.VIII.1981 & 30.VIII.1981, *O.M.Afonina* (KRAM, LE); Anadyr River, Carvaljanskaya Creek, 23.VII.1982, *O.M.Afonina* (LE); Palajvaam River (Anadyr Ridge), 13 & 25.VII.1989, *O.M.Afonina* (KRAM, LE); Getlyanen River, 3.VIII.1976, *O.M.Afonina* (LE); Senyavin Strait, Arakamchechen Island, 11.VII.1976, *O.M.Afonina* (LE); Penkingei Bay, Peszovaya Creek mouth, 11.VII.1978, *Katenin* (LE); Senyavin Strait, vicinity of Yanrakynnot settlement, 20 & 23.VII.1976 *O.M.Afonina* (KRAM, LE).

Distribution. Recently described *Grimmia jacutica* is not rare in eastern Asian Russia, from Taimyr and Enissej River basin to Chukotka and Primorskij Territory, and also known from Alaska in North America. It is rather common in the montane areas of Yakutia. *Grimmia jacutica* occurs in a wide elevation range, from sea level to 1700 (-2100) m alt., in arctic tundrae and mountains, in the forest belt (larch, more rarely spruce forests)

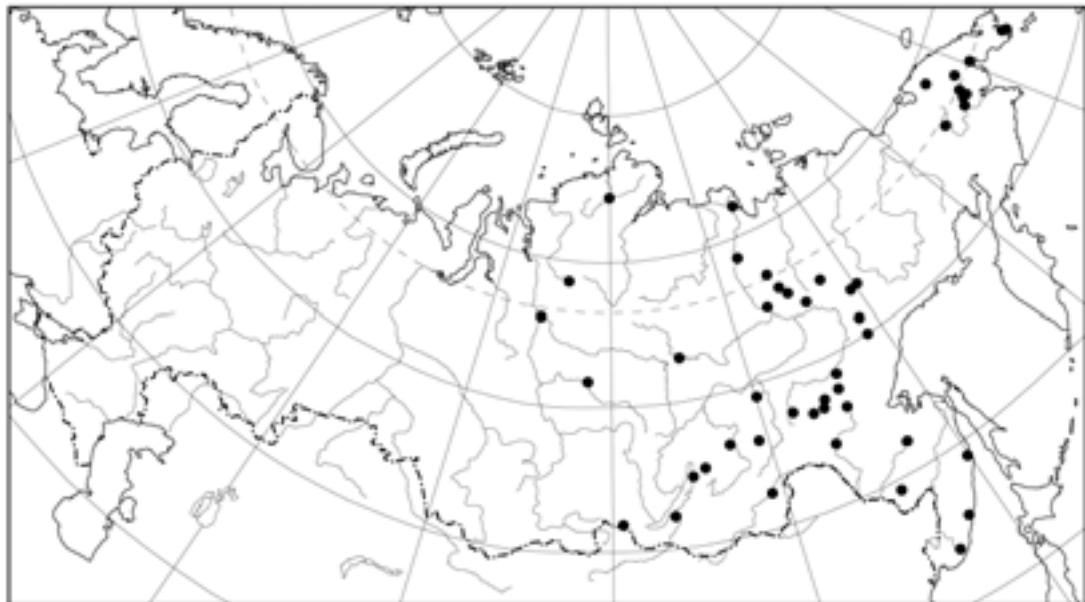


Fig. 25. Distribution of *Grimmia jacutica* Ignatova, Bedn.-Ochyra, Afonina & Muñoz in Russia

and in alpine tundra, mostly on rock-fields, on rocks and in crevices between them, usually in dry habitats; in arctic tundra also on soil.

Differentiation. Large plants and ribbed capsules on arcuate setae of *G. jacutica* resemble those of *G. elatior* (part of collections were placed in herbaria under the latter name), but it can be easily separated from the latter by weaker, mostly bistratose costa, reniform in cross section, with 3-5 ventral epidermal cells (vs. strong, 3-5-stratose, irregularly angular in cross section, with 2 ventral epidermal cells costa in *G. elatior*), unistratose leaf lamina, bistratose for only one cell row at margins (vs. mostly bistratose, 3-5-stratose at margins in *G. elatior*), upper laminal cells never papillose or bulging (vs. usually papillose and often bulging in *G. elatior*). Reniform costa is characteristic for *G. longirostris*, but this species differs in smaller plants, ca. 1-3 cm high, in dense cushions (vs. plants 4-5 cm high, in loose patches in *G. jacutica*), usually bistratose lamina in distal part of leaf (vs. always unistratose lamina, bistratose only in one cell row at margins in *G. jacutica*), hyaline hair-points terete (vs. widened and flattened at base in *G. jacutica*), and frequent sporophytes, cylindric, smooth capsules on erect setae (vs. usually lacking sporophytes in *G. jacutica* and, if present, capsules ovoid, ribbed, on arcuate setae). The peculiar cell areolation of *G. jacutica*, composed of elongate rectangular cells

with pale, strongly incrassate and sinuose longitudinal walls and contrastingly very thin transverse walls resembles *Racomitrium* cell areolatin. Furthermore, the apparently lateral perichaetia caused misidentification of many *Grimmia jacutica* collections, that were identified mostly as *Racomitrium sudeticum*. However, the sinuosity of the longitudinal walls in *Racomitrium* species is different, more regular, with smaller period of «sinusoid». *Racomitrium sudeticum* further differs from *G. jacutica* in lacking the large area of strongly incrassate, porose, not sinuose basal juxta-costal cells, and its often 3-stratose costa.

Several specimens from three coastal localities from extreme East of Chukotka and West of Alaska differ from other collections of *G. jacutica* in more robust plants with appressed leaves, straight hair-points and 3-4-stratose costa (Fig. 24). In other characters these specimens agree with *G. jacutica*. This species is not very variable, but in few populations the plants with very short or completely absent hyaline hair-points were found.

14. *Grimmia laevigata* (Brid.) Brid., Bryol. Univ. 1(1): 183. 1826. — *Campylopus laevigatus* Brid., Muscol. Recent. Suppl. 4: 76. 1818 [1819]. — *Grimmia campestris* Burchell ex Hook., Musci Exot. 2: 129. 1819. — *Grimmia leucophaea* Grev., Mem. Wern. Nat. Hist. Soc. 4: 87, pl. 6. 1822. Figs. 26, 27.

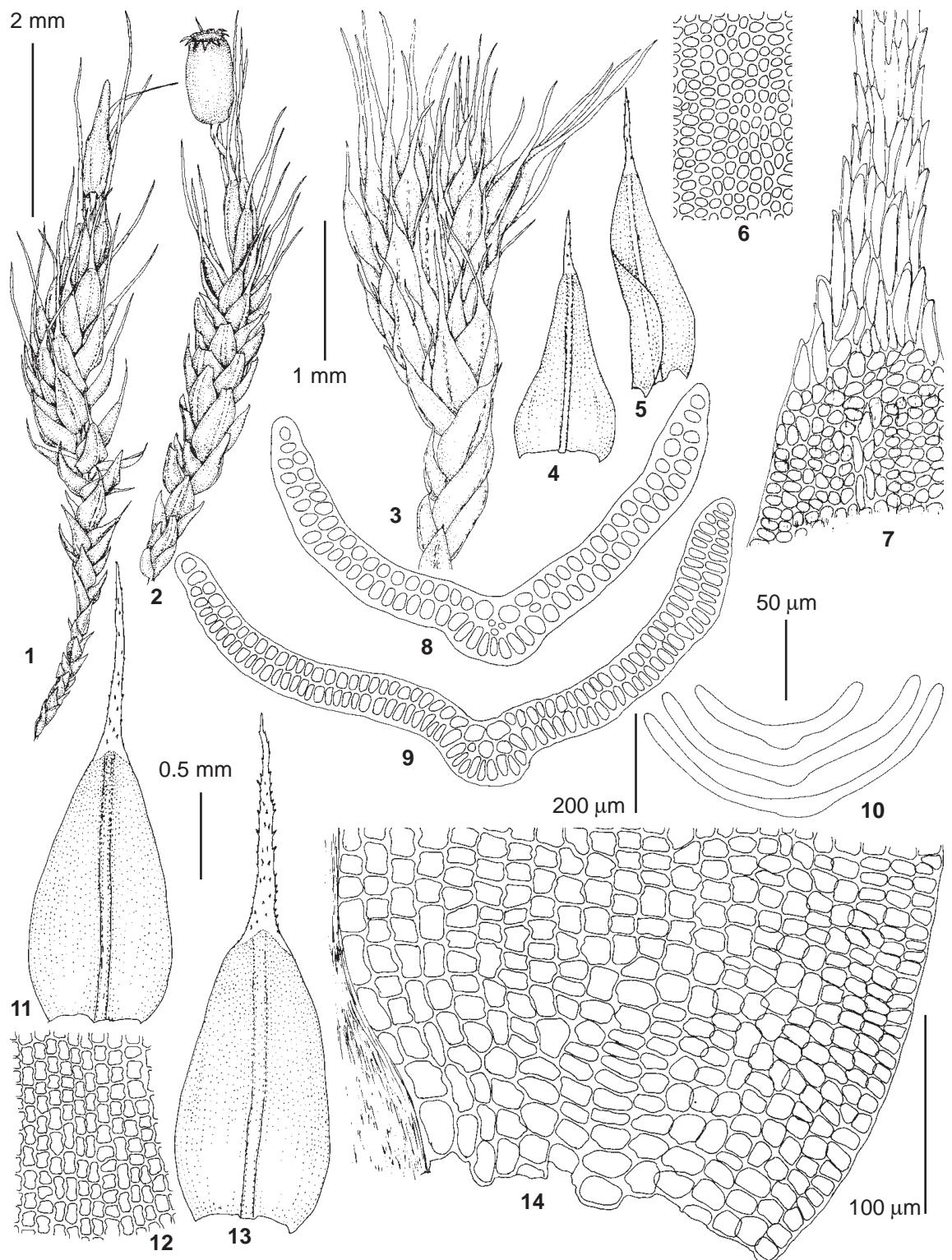


Fig. 26. *Grimmia laevigata* (Brid.) Brid. (1-2, 5, 11-13 – from Altai Republic, M.Ignatov, #35/11; 3-4, 6-10, 12, 14 – from Bashkortostan, E.Ignatova, #13/96): 1-3 – habit; 4-5 – lower leaves; 6 – upper leaf cells; 7 – base of hair-point and upper leaf cells; 8-10 – leaf transverse sections; 11, 13 – upper leaves; 12 – median leaf cells; 14 – basal leaf cells. Scale bars: 2 mm for 1-2; 1 mm for 3; 0.5 mm for 4-5, 11, 13; 50 µm for 6-9; 100 µm for 6-7, 12, 14; 200 µm for 10.

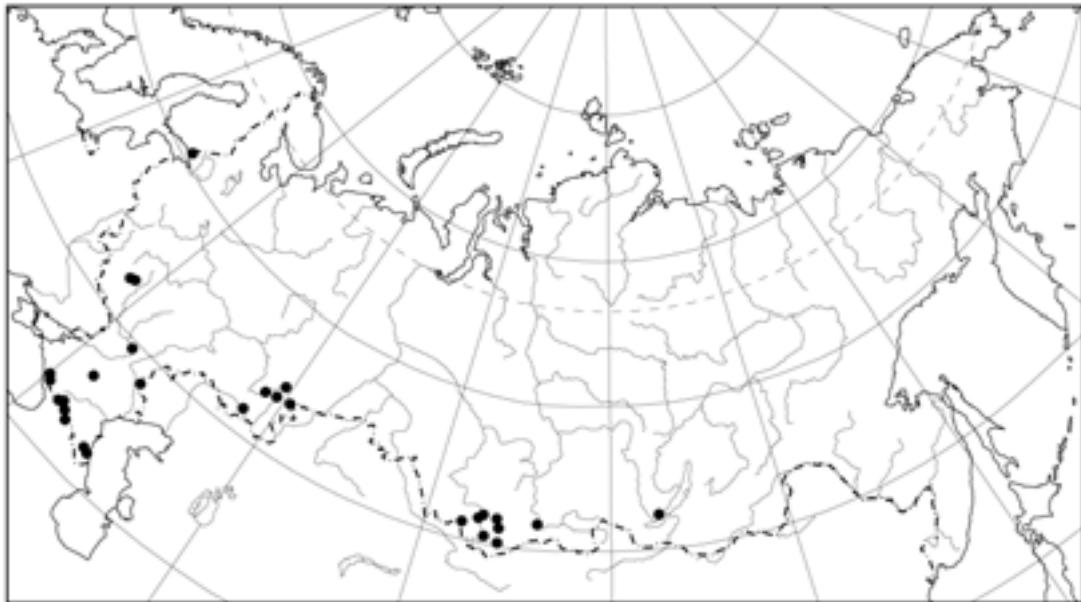


Fig. 27. Distribution of *Grimmia laevigata* (Brid.) Brid. in Russia.

Plants in dense, easily separating tufts, dark green or blackish, usually very hoary. Stems erect, 1-2 cm long. Leaves gradually enlarged to the distal part of shoot, 1.5-2.0(-2.5)×0.5-0.7 mm, ovate-triangular, shortly acuminate to obtuse, widely concave, not plicate; margins plane; costa weakly differentiated distally, flat, semi-elliptic in cross section, (2)-4-6 cells wide ventrally, widened at leaf base; hyaline hair-points in upper and perichaetial leaves long (sometimes as long as lamina), terete distally, widened and flattened proximally, usually decurrent, sharply and densely denticulate; lamina bistratose in distal 2/3, with 1-2 marginal cell rows unistratose; upper cells isodiametric, 6-8 µm, with moderately thickened walls, median cells short rectangular, slightly sinuose, basal juxta-costal cells short rectangular, slightly porose, basal marginal cells oblate mixed with quadrate. Dioicous, sporophytes very rare. Setae straight, 2-3 mm. Capsules emergent to exserted, oblong-cylindric, 0.7-1.0 mm long, smooth to wrinkled when dry. Operculum conic, rostrate. Annulus of affinis-type. Peristome teeth cleft distally, papillose. Spores 12-16 µm. Calyptrae mitrate.

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:** **Leningrad Province**, Viipori [Vyborg], V.1875, E. Lang (H); **Orel Province**, Livny Distr., Navesnoe village, Kuzilinka, 28.VI.1999, V. Zolotov (MHA); **Lipetsk Province**, Stegalovka village, Svishnya Creek, «Kamennyj Les», 7.VI.1986, N.N. Popova (MHA); **Orenburg Province**, Belyaevskij Distr., Burlykskij, 20.V.1990, N. Shevyreva & T. Konovalova (MHA); **Volgograd Province**, Kletskij Distr., Kremenskaya, 7.VIII.1999, Ignatov (MHA); **Astrakhan' Province**, Bogdo, Krasnaya balka, 9.V.1997, I.Zemlyanskaya (MHA); Kalmykia, Calon-Khomur, 18.IX.1924, K. Beguckow (LE); **CAUCASUS: Dagestan**,

prope pagum Tanti, 19.VII.1898, Th. Alexeenko (LE); Distr. Samur, pr.p. Fija, 19.VIII.1900, #9256, Th. Alexeenko (LE); between Derbent & Khuchni, 22.VI.1961, A. Bobrov (LE, MW); Bujnaksk Distr., Kafyrkumukh Ridge, near Kafyrkuukh Rv. St., 28.IX.1956, Ya. Prokhanov (LE, MW); **Kabardino-Balkaria**, Sovetskij Distr., Bezengi Gorge, 6.VII.1988, #46, N. Portenier (MHA); Baksan River at Adyl-Su Creek mouth, 30.VII.2004, Ignatov & al. (MHA); Baksan River near Bylym, 30.VII.2004, Ignatov & al. (MHA); Baksan River near Lazhkuta, 30.VII.2004, Ignatov & al. (MHA); Cherek Bezengijskij River near Dumala Creek mouth, 1.VIII.2004, Ignatov & al. (MHA); **North Ossetia**, Lars ad fl. Terek, V.F. Brotherus (H-BR); Kobi ad fl. Terek, A.H. & V.F. Brotherus (LE); **Karachaevo-Cherkessia**, Teberda Reserve, Ullu-Murudzhu Gorge, 9.VIII.1986, Ignatova (MW); Dzhemagat Gorge, 10.VII.1994, #29/94, Onipchenko (MW); Mukhu Gorge, 17.VIII.1955, A.L. Abramova & I.I. Abramov (LE, MW, MHA); M. Khatipara Gorge, 2.VII.1994, #2/94, Onipchenko (MW); Malaya Khatipara Gorge, 10.VIII.1955, A.L. Abramova & I.I. Abramov (LE, MW); Malaya Khatipara Mt., 22.VII.1977, Onipchenko (MW); Nizhnyaya Teberda, 3.VII.1994, #6/94, 7/94, 8/94, Onipchenko (MW); Kuban' River upper course, 21.VIII.1955, V.V. Skripchinskij (LE); **Krasnodar Territory**, Malaya Laba River basin, Sergiev Gaj Ridge, 26.VI.2003, T. Akatova (CSR, MHA); **URALS: Bashkortostan**, Khajbullinskij Distr., Shajtantau Range, Usergan, 19.VI.1991, #21, A. Muldashev (MHA); Uchaly Distr., Komsomolskij, Irendyk Range, 4.IX.1990, Ignatova (MHA); Beloretsk Distr., Bretjak, 12.IX.1990, #13/24, 13/96, Ignatova (MHA); **Chelyabinsk Province**, Magnitnaya Mt., 21.VI.1929, V. Korzhevin & I. Blumental (LE); **SIBERIA: Altai Republic**, Chagan-Uzun, 23.VII.1996, L.V. Bardunov (MHA); Chuya River, #B-65166, T.S. Elias & al. (NY); Malyj Yaloman, 30.VII.1991, #25/145, Ignatov & Ignatova (MHA); Saratan, 4.VIII.1993, #36/349, Ignatov (MHA); Chulcha River, Nepristupnyj waterfall, 10.VII.1991, #9/163, Ignatov (MHA); Charysh River, 11.VII.1913, #1928, N.I. Kuznezow (LE); Ust-Sema,

29.VI.1991, #24/151, *Ignatov & Ignatova* (MHA); Teletzkoe Lake, Izvestkovaya Mt., 12.VI.1989, #0/945, *Ignatov* (MHA); Teletzkoe Lake, Kobykhta, 12.VI.1989, #0/462, *Ignatov* (MHA); Gorno-Altaisk, 18.VII.1993, #35/11, *Ignatov* (MHA); Gorno-Altaisk, 26.VII.1991, #23/13, 23/14, *Ignatov* (MHA); **Krasnoyarsk Territory**, Western Sayan Mts., Malaya Ury Creek, 1.VIII.1968, *L.V.Bardunov* (IRK); Minussinsk, 9.VII.1894, #84, *N.Martianov* (H-Br, LE); **Irkutsk Province**, lacus Baikal, supra pagum Bolshie Koty, *L.Pujmanova* (ALTA).

Distribution. *Grimmia laevigata* is known from xeric areas throughout the world, including Europe, Africa, Middle East, China, Mongolia, North and South America, Australia, New Zealand, Oceania. In Russia the species is rather common in xeric areas of the Caucasus; scattered localities are known from steppe and forest-steppe zones of European Russia and South Urals, it is sporadic in Altai Mts., and few collections were made in Western Sayan Mts. and Baikal Lake surroundings. It grows on exposed, dry, mostly non-calcareous rocks.

Differentiation. *Grimmia laevigata* is almost always found in Russia in sterile condition (plants with sporophytes were found only once in Altai Mts.). Gametophyte characters of *G. laevigata* are very similar to that of *G. tergestina* or *G. poecilostoma*, species also rarely forming sporophytes. The main diagnostic characters of *G. laevigata* are oblate and not translucent basal marginal cells (vs. short rectangular and quadrate, translucent basal marginal cells in *G. tergestina*, *G. poecilostoma*, and also *G. ovalis*). *Grimmia laevigata* differs from all these species in mostly triangular lower leaves, much more distinctly enlarged to the proximal part of shoot (lowermost leaves are scale-like, with very short hyaline hair-points), and usually longer and more dentate hyaline hair-points.

15. ***Grimmia longirostris*** Hook., Musci Exot. 1: 62. 1818. — *Grimmia affinis* Hoppe et Hornsch. in Hornsch., Flora 2: 85, 443. 1819. — *Grimmia ovata* auct. non Web. et Mohr. — *Grimmia cavifolia* Lindb. et Arnell, Kongl. Svenska Vetenskapsakad. Handl. 23(10): 103. 1890. Figs. 28, 29.

Plants in dense cushions or in dense to loose tufts, olive-green, yellowish-green or dark green to blackish, moderately hoary or sometimes very hoary. Stems erect, 1-3 cm long. Leaves loosely appressed and slightly flexuose when dry, 1.3-2.0(-2.5)×0.4-0.7 mm, from ovate base gradually tapering into lanceolate acumen, acuminate, obtusely keeled distally; margins plane in distal part of leaf, recurved at one side in

proximal and middle part and plane or shortly and narrowly recurved on the other side, more rarely recurved on both sides; costa weakly differentiated in distal 1/3, clearly differentiated from the middle part of leaf to the base, prominent dorsally, canaliculate ventrally, reniform in cross section, with (3)-4-6(-8) ventral epidermal cells; hyaline hair-points from short to rather long (very rarely absent), terete, straight to slightly flexuose, denticulate, not decurrent; lamina (1)-2(-3)-stratose in distal 1/3, unistratose with bistratose strips in middle part, unistratose at base; upper laminal cells isodiametric, 8-10 µm, with moderately thickened and slightly sinuose walls, median laminal cells short rectangular, with sinuose walls, basal juxtacostal cells elongate rectangular, with thickened, porose walls, becoming shorter to the margin, basal marginal cells rectangular, pellucid, with thin longitudinal and thick transverse walls (sometimes basal marginal cells or almost all basal cells are short rectangular to quadrate). Autoicous, androecia terminal, sporophytes frequent. Setae 2-4 mm, straight. Capsules exserted, ovoid-cylindric, 1.2-1.5(-2) mm long, smooth. Operculum low conic, with short to long obtuse beak, straight or oblique. Annulus of affinis-type. Peristome teeth orange, densely papillose, cleft or perforated distally. Spores 8-12 µm. Calyptrae cucullate.

SPECIMENS EXAMINED: **EUROPEAN RUSSIA:** Murmansk Province, Salla, 21.II.1937, Vaarama (H); Lapponia Murmanica, Varsina, VIII.1887, V.F.Brotherus (H); Kola, 17.VII.1867, Fellman (H); Petsamo Lappmark [Rybachi Peninsula], 15 & 19.VII.1937, Hayren (H); Khibiny Mts., Kuelpor, 5.IX.1948, #2305b, Shlyakov (LE); Lapponia Imandrae, ad lacum Umpjawr, 17.VII.1892, #607, Kihlman (LE); Kandalaksha Bay, Kem'-Ludskij Island, 12-15.VIII.1989, #102-7-89, 188-7-89, 188-2-89, Belkina & Likhachev (KPABG); Velikij Island, 20.VIII.1992, #69-4-92, 71-15-92, Likhachev (KPABG); Ryazhkov Island, 3-4.VIII.1988, #371/4, 391-12-88, Shlyakov (KPABG); Olenij Island, 26-30.VII.1988, #19/20, 239/2, 307/6, 307/12, 319/15, Belkina & Likhachev (KPABG); Ponoj, 29.VII.1972, #329, Shlyakov (KPABG); Kovdor, 13.VII.1977, #120, Shlyakov (MHA); Pyukhyakuru Gorge, 5.VIII.1986, #27/27, Belkina & Likhachev (KPABG); Khibiny Mts., Lovchorr, Pirrotinovoe Gorge, 9.VIII.1948, #207, Shlyakov (LE); Aikuivumchorr, 23.VI.1948, #1520, Shlyakov (LE); Rasvumchorr Mt., 17.VIII.1977, #1171, Shlyakov (KPABG); Kukisvumchorr, 25.VII.1947, #572, 4.VIII.1948, 1976, Shlyakov (LE); Kukisvumchorr, 4.IX.2001, Ignatova (MW); Vudjavrchorr, 17.VII.1947, #253, # RS-53-47, Shlyakov (LE); Yuksporlak Pass, 30.VI.1948, #1608a, Shlyakov (LE); Chiltald Mts., Malaya Konja Mt., 11.VII.1988, #207-6-88, Belkina (KPABG); Chil' Stream, 9.VII.1988, #171-5-88, Belkina (KPABG); Lava-Tundra Mts., 10.VIII.1987, #333-7-87, 333-12-87, Belkina (KPABG); Karelia, Petrosavodsk, 1863, Simming (LE); Suojarvi, 20.VI.1870, Norrlin (H); Ladoga Lake, 21.V.1890, Birulya (LE); Sandal Lake, 11.VII.1920, 15.VII.1920, 18.VIII.1920, L.I.Savicz (LE); Segozero, 1.VII.1921, L.I.Savicz (LE); Ruhajarvi, Seesjarvi, Vilsajarvi,

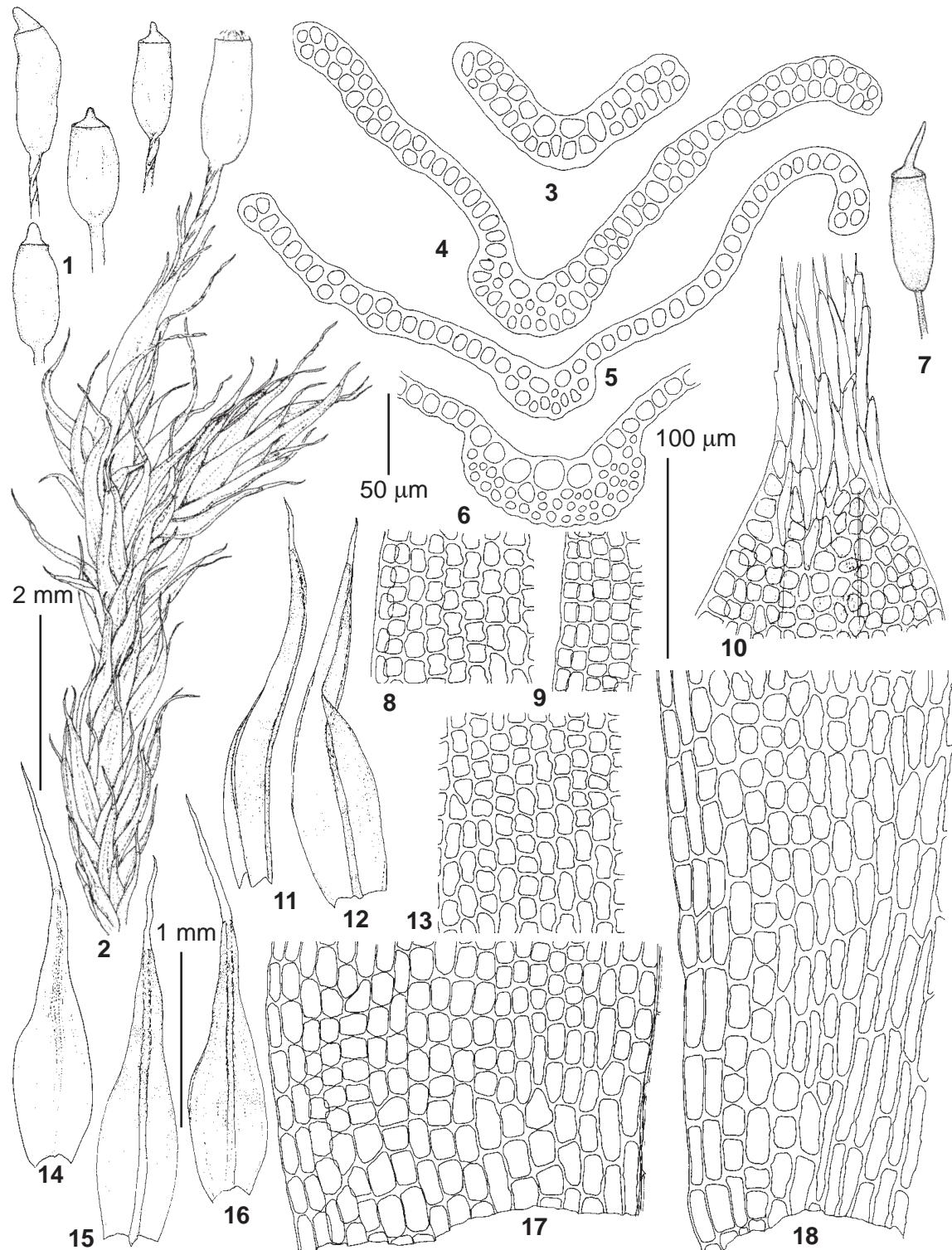


Fig. 28. *Grimmia longirostris* Hook. (1-2, 8 – from Perm Province, A. Bezgodov, # 144; 3-6, 9-16, 18 – from Perm Province, A. Bezgodov, #378; 7 – from Tuva Republic, 9.IX.1999, T. Otnyukova; 17 – from Ekaterinburg Province, 1.VII.1999, I. Goldberg): 1, 7 – capsules; 2 – habit; 3-6 – leaf transverse sections; 8-9 – upper leaf cells; 10 – base of hair-point and upper leaf cells; 11-12, 14-16 – leaves; 13 – median leaf cells; 17-18 – basal leaf cells. Scale bars: 2 mm for 1-2, 7; 1 mm for 11-12, 14-16; 50 µm for 3-6; 100 µm for 8-10, 13, 17-18.